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SERIE: PLANKTON · BIND III

NR. 2. P. JESPERSEN: THE FOOD OF THE HERRING IN THE WATERS ROUND BORNHOLM

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THE FOOD OF THE HERRING IN THE WATERS ROUND BORNHOLM

BY

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I. Introduction.

In the year 1931 the herring fishery at Bornholm yielded an uncommonly small profit. The herring found in the waters round this island were not only comparatively few in number, but the size and quality of the fish in the said year were of an extremely low standard.

On the initiative of Mr. H. Blegvad, Dr. phil., Director of the Danish Biological Station, a small number of herring from the waters round Bornholm was collected in the summer of 1931 for the purpose of examining their stomach contents, and at the same time some plankton samples were taken. But it was not until the summer of 1932 that a more regular collecting of herring stomachs was started for the purpose of following the fluctuations in the quantity of herring food and in its composition at different seasons of the year. As a rule the stomachs of about 20 to 40 herring were taken twice or thrice a month, and after preservation in formalin they were sent to the Plankton Laboratory for examination. In this way the stomachs of about 4,600 herring were analysed. The gutting of the herring and the preservation and dispatching of the stomachs was carried out by Mr. Andreas Koch, Gudhjem, who performed no small work in procuring the material necessary for the investigation throughout a period of $3^1/_2$ years.

Figure 1. Map of Bornholm showing the stations at which plankton samplings were carried out, the hatching denoting the approximate limits of the area in which herring were caught for the stomach analyses.

As already mentioned the investigation was undertaken under the auspices of the Danish Biological Station; the stomach analyses and examinations of plankton samples were carried out by the Plankton Department of Kommissionen for Danmarks Fiskeri- og Havundersøgelser.

No plankton samples were collected at the times and places at which herring were caught for stomach analyses, and so it was out of the question to compare the composition and quantity

Table 1.

Monthly yields in kgs. of the herring fishery at Bornholm in the years 1926—1935.

	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
January.....	92,500	26,500	166,500	46,000	24,700	7,400	43,200	12,200	19,900	92,900
February.....	53,200	37,500	211,700	5,800	37,200	7,900	57,000	22,700	18,500	251,500
March.....	55,000	58,000	194,800	4,700	21,500	26,500	57,300	33,800	15,000	204,000
April.....	37,900	160,000	132,000	42,300	44,400	56,800	113,200	68,000	67,000	219,000
May	287,000	279,000	266,000	303,000	517,000	252,000	166,000	256,000	301,000	422,000
June.....	198,200	353,000	340,000	501,000	740,000	272,000	291,000	339,000	582,000	651,000
July.....	300,000	487,000	557,000	516,000	447,000	240,000	403,000	420,000	675,000	604,000
August.....	221,000	355,000	599,000	612,000	334,000	218,000	333,000	371,000	539,000	539,000
September....	128,000	247,000	326,000	343,000	456,000	217,500	245,000	172,000	320,000	372,000
October.....	25,500	80,000	97,000	133,000	128,000	105,400	103,800	48,300	110,800	264,300
November	8,900	122,000	55,600	44,000	13,400	38,400	25,300	22,200	67,800	115,800
December	2,000	105,000	49,700	27,700	9,400	26,100	23,200	11,450	40,200	128,100
Total...	1,409,200	2,310,000	2,995,300	2,578,500	2,772,600	1,468,000	1,861,000	1,776,650	2,756,200	3,863,600

Figure 2. Total yield in 1,000 kgs. of the herring fishery at Bornholm in the years 1926—1935 and, represented by the hatching, the yield of the drift-net fishery in the months of May—August (inclusive).

of the herring food with that of the plankton. It is true that plankton samples were taken in the waters round Bornholm in the summers of some few years, but these samples are so few in number, that it was impossible to carry out a more thorough investigation of the said kind.

On the map Figure 1 the stations are put down at which plankton samplings were carried out; the hatching denotes the area in which samples of herring were taken for the stomach analyses.

During the last 10 years the herring fishery at Bornholm returned highly varying yields as will appear from Table 1, which shows the monthly yields of the years 1926—1935.

It is seen that the heaviest quantities are landed in summer, during the period from May to August or September. During this time by far the greater part of the herring is caught in drift-nets, but throughout the rest of the year the principal gear is the setting net. In Figure 2 the total yields of the respective years are shown in a graphical way with a special hatching for the yield of the period from May to August (inclusive), the months of the most intense drift-net fishery.

In the years 1926—1930 we find a fairly uniform rise of the yield, but in 1931 the figures fall most rapidly to about half the yield of the years immediately preceding. As late as 1932 and 1933 the yield is comparatively small, but in 1934 and especially in 1935 another rapid rise sets in. As far as the drift-net fishery of the months May—August (inclusive) is concerned a distinct rise of the yield can be traced from 1931 to 1935, and the remarkably small yield of the herring fishery in 1931 appears most clearly from the graphic representation. It was already mentioned that in 1931 both the size and the quality of the herring were extraordinarily poor. According to the official Danish Fishery Report the quality of the herring was better in 1932 than in 1931 and better in 1933 than in 1932: in the waters round Bornholm there seems to be a rise of both quantity and quality of the herring during the years from 1931 to 1933.

II. The Relative Numbers of Feeding Herring in the Different Months.

During an examination of the stomach contents of the herring several samples turned out to contain some herring without any food in their stomachs. So it is of interest to find out the proportion between the number of feeding herring and the number of herring stomachs examined during the different months in which examinations were carried out within the period 1932—35. Table 2 gives the relative quantities of feeding herring in the respective months and the average monthly percentages of feeding herring, calculated from the total material of the said years.

Table 2.

Monthly percentages of feeding herring in the years 1932—35.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	89.3	40.0	46.8	28.8	57.2	58.2
1933.....	51.8	60.2	89.3	95.1	100.0	98.7	96.8	63.7	38.7	18.2	51.7	51.7
1934.....	55.8	55.7	100.0	..	99.3	92.5	83.6	79.9	56.8	19.5	42.4	72.4
1935.....	71.0	74.5	81.2	100.0	98.8	100.0	62.7	54.4	34.2	21.5	48.1	71.5
Mean...	59.5	63.5	90.2	97.5	99.4	97.1	83.1	59.5	44.1	22.0	49.8	63.4

Further, the monthly percentages of the respective years are shown graphically in Figure 3.

As will appear from the figure the highest relative number of feeding herring is found in spring and early summer, i. e. from March to June or July, a comparatively small number occurring in autumn with a distinct minimum in October in all 4 years of investigation. Between March and July by far the greater part of the herring, from 90 to 100 %, was found to contain food, more particularly in April, May and June when practically all herring had food in their stomachs. From July to October the relative quantity of feeding herring declines most rapidly, a minimum of about 20—30 % occurring in the latter month. Already in November another rise is noted, about half the herring examined proving to have stomach contents, and in the winter months December, January, and February the quantity rises to between 50 and 70 %.

Besides the investigations already mentioned stomach analyses of a comparatively small number of herring were carried out in August and September, 1931, the numbers amounting

to 49 herring in the former and 35 herring in the latter month. Of these herring remarkably few specimens had food in their stomachs, viz. 20.7 % in August and 14.1 % in September. A comparison with the relative quantities of feeding herring in the respective months of the years 1932—35 shows us that in 1931 the number of feeding herring was comparatively much smaller than in the following years as will appear from the following survey.

	1931	1932	1933	1934	1935
August	20.7 %	40.0 %	63.7 %	79.9 %	54.4 %
September	14.1 -	46.8 -	38.7 -	56.8 -	34.2 -

By calculating the average percentages of feeding herring in the years 1932—35 we get 59.5 % for August and 44.1 % for September, which shows us that on an average the number of feeding herring in August and September of the years 1932—35 is 3 times greater than in the corresponding months of 1931. So we have established a most interesting fact: in 1931, the year in which the herring fishery at Bornholm returned an uncommonly small profit and the size and quality of the herring was particularly poor, the feeding herring were remarkably few in number.

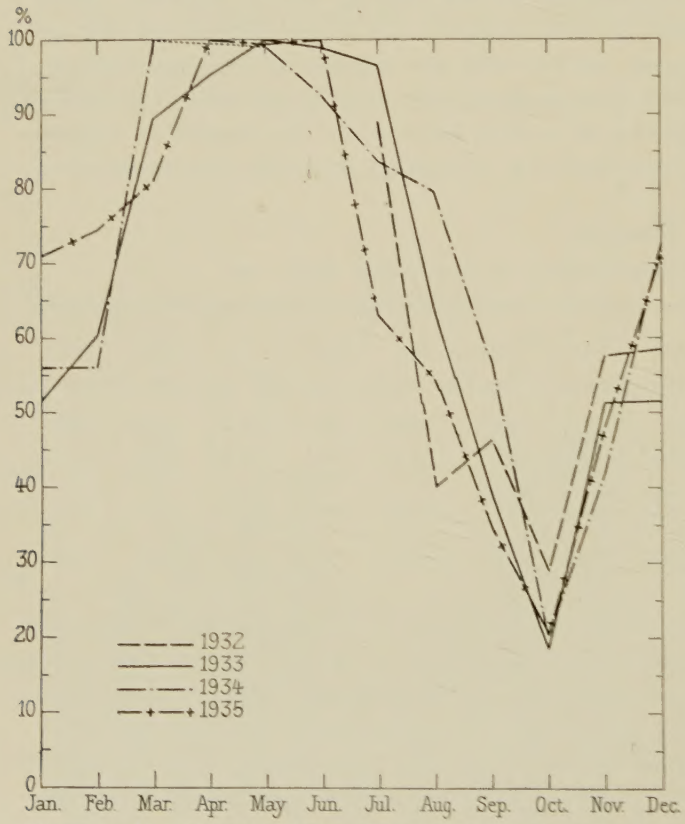

Figure 3. Monthly percentages of feeding herring in the years 1932—35.

It is of course an obvious supposition that the comparative scarcity of feeding herring in 1931 should be put down to the fact that in the said year the water contained comparatively smaller numbers of food organisms of the herring than in the following years. Unfortunately, the plankton investigations carried out cannot be used for an absolute corroboration of this explanation as the plankton samples collected in 1931 and 1932 date from somewhat different times, viz. from the end of August and the middle of July, respectively. A detailed survey of the numbers of organisms will be found in a following chapter, but if we look apart from the varying dates, the state of things mentioned above calls attention to the fact that on an average the volumes of plankton and the numbers of copepods, which must be considered some of the principal food organisms of the herring, are much larger in 1932 than in 1931. This appears from the following survey of volumes and the numbers of copepods in hauls from bottom to surface with the Hensen Net at two stations from respectively 1931 and 1932, showing approximately the same position (see map Figure 1, p. 3).

1931 (St. 2972, 29/VIII). Volume: 18 c.c. No. of copepods: 25,130 specimens
1932 (St. 3374, 17/VII). — : 26 c.c. - - — : 54,560 —

Judging by the plankton examinations available there seems to have been comparatively little plankton (herring food) in the water in 1931, and this is most probably the cause of the comparative scarcity of feeding herring and of the herring fishery of this year yielding so light catches. This supposition is confirmed by the facts established by English investigations in the North Sea (see *i. a.* HARDY, 1926, and SAVAGE, 1931): here there is a good relation between the abundance of planktonic food and the quantity and quality of the herring.

III. Quantitative Investigations on the Herring Food.

Together with the qualitative analyses of the stomach contents of the individual herring the volume of the food amount was measured after settlement. Of course this determination of volume conveys only a rough impression of the amount of food owing to the varying degree to which the different plankton organisms pack in settling. In many cases, however, the quantities to be measured were so small, that it was practically impossible to determine the volumes by displacement although of course the latter method would have expressed the volume more exactly.

In Table 3 are stated (in c.c.) the monthly mean volume of food per feeding herring in the years 1932—35 and the total mean volume per month, calculated from the average figures of the respective months.

Table 3.

Monthly mean volumes of food in c.c. per feeding herring.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	0.39	0.04	0.26	0.04	0.29	0.49
1933.....	0.25	0.19	0.79	0.69	0.56	0.24	0.42	0.28	0.16	0.03	0.12	0.10
1934.....	0.27	0.32	2.75	..	1.07	0.53	0.59	0.72	0.91	0.10	0.30	1.30
1935.....	0.87	1.22	0.15	2.98	0.43	0.87	0.44	0.53	0.08	0.02	0.31	0.39
Mean...	0.46	0.58	1.23	1.83	0.68	0.55	0.46	0.39	0.35	0.05	0.25	0.57

As will appear from the table we find a distinct maximum of the food amount per herring between February and May: in 1933 and 1934 the maximum occurs in March, and 1935 in April. However, within the said time between February and May there are considerable fluctuations in the average figures of the different months, more particularly in 1935 when the mean volumes of February and April were 1.22 and 2.98 c.c., respectively, the month of March showing the small volume of 0.15 c.c. This is due to a different composition of the food in the various months.

If we will now make a comparison between the relative quantity of feeding herring and the average food amount per feeding herring in the respective months, we use the mean numbers of feeding herring given in Table 2 (p. 5) together with the mean volumes of the table above, which figures are in both cases based on the total material of the respective months of the years

1932—35. In this way we get the two graphs shown in Figure 4, the upper graph showing the percentage amount of feeding herring, the lower one the volume of food per feeding herring.

In the main the two graphs take the same course; however, the highest relative quantity of feeding herring is found between March (April) and June, but a distinct maximum of the food amount is found already in the months of March and April. In May the volume of food decreases rapidly and continues to fall rather regularly until October; in the latter month we find a distinct minimum of the food amount corresponding to a distinct minimum in the comparative quantity of feeding herring in the same month.

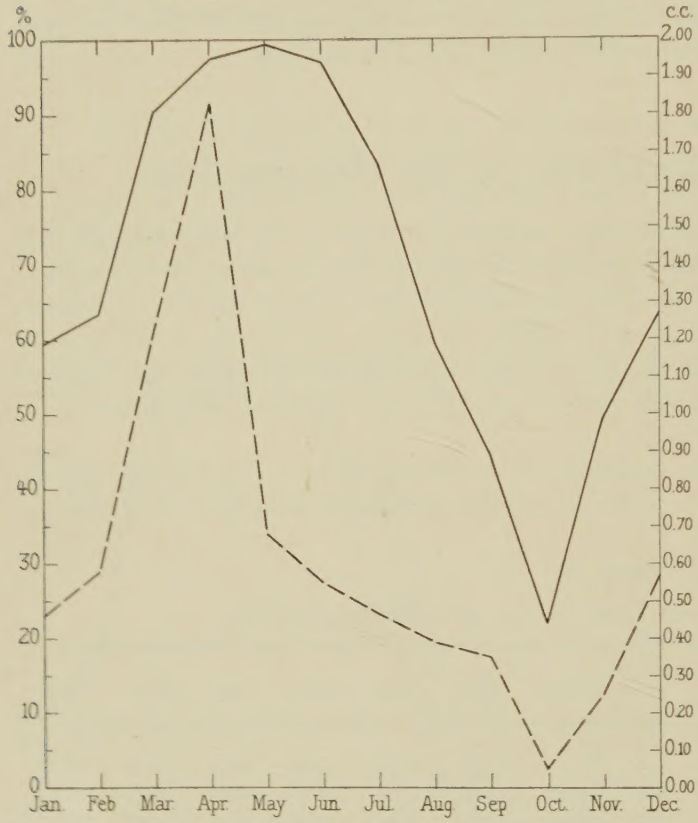

Figure 4. Relative quantity of feeding herring (———) and mean volume of food per feeding herring (— — —), based on the total material of the years 1932—35.

It seems to appear from the above that the appetite of the herring is far better in the months of March and April than in May and the following summer months. Possibly, this is really the case, but attention should be called to the fact appearing from the following, that the composition of the food in the early spring months differs widely from the composition in summer: in March and April most of the food in a quantitative respect consists of young fish, especially *Ammodytes*; but in the summer months the latter are nearly totally absent, the food at this time principally consisting of comparatively small organisms like copepods and cladocerans. At the season in which larval stages of *Ammodytes* and other pelagic fish larvae are found it is quite obvious that the herring prefers to feed on these young fish, but later in the year it will have to content itself with small crustacea like copepods and cladocerans. Late in summer the stomachs are not by far so distended by food as in early spring, and this is no doubt due to the fact that it is much easier to fill the stomach with the comparatively large youngs of fish than with small crustacea like copepods. In the time between May and August we find comparatively many feeding herring, but in these months, as compared with the months of March and April, there is but a small amount of food in the stomachs of the herring; as already mentioned this is no doubt exclusively due to the varying composition of the food.

As demonstrated above we found in October a close agreement between the small number of feeding herring and the small amount of food per feeding herring; in November and December there is a distinct rise of both these factors. On the whole the volume of food in these months and in January and February is larger than in late summer and autumn, undoubtedly because

in some of the winter months the herring principally feed on larger crustacea, particularly mysids, the latter in a quantitative respect being of far greater importance as food matter than smaller crustacea like copepods and cladocerans.

IV. Feeding in Relation to Development of Genital Organs.

The present investigations concerning the degree of maturity in the herring are based exclusively on material preserved in formalin, and so the maturity degree could only be determined approximately. Furthermore, it was impossible to establish the size (length) of the herring, the material sent to the Laboratory containing only the intestines with the genital organs; but the guts in all cases originated from marketable fish, and so the lengths presumably average about 18—22 cms. For these reasons it was impossible to use the system generally applied for determining the maturity of fresh material (see *i. a.* Heincke, 1898, Tabellen und Tafeln p. VII, and Johansen, 1923, p. 5, and 1924, p. 4), but for the purpose of getting an expression for the maturity stage of the genital organs their maximal breadth in mm. was measured by means of a pair of dividers. Of course such measurings of a preserved material cannot be very exact,

Table 4.

Maximal breadth of genital organs of herring from the various months of the year.

mm.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
27	..	..	..	..	..	..	..	..	2	..	..	..
26	..	..	..	..	..	..	..	..	..	..	..	..
25	..	..	..	..	..	..	..	..	..	3	..	..
24	..	..	..	..	..	..	..	..	3	3	..	..
23	..	..	..	..	..	..	1	3	2	3	..	..
22	..	..	..	..	..	..	..	3	7	3	..	..
21	..	..	..	..	..	..	4	1	9	5	..	..
20	1	1	..	..	..	..	2	8	10	8	..	..
19	..	..	..	..	..	..	3	5	13	6	..	..
18	..	2	..	1	..	1	6	13	19	9	..	..
17	2	2	1	1	..	3	9	13	18	9	1	2
16	2	3	..	..	4	2	8	26	26	10	..	4
15	3	1	1	2	6	5	10	20	23	14	3	3
14	4	3	2	1	8	3	18	27	23	4	4	7
13	2	4	2	3	10	3	27	27	20	3	3	4
12	6	4	1	4	11	7	35	26	19	6	4	3
11	1	11	2	6	9	13	42	28	11	3	2	2
10	3	7	5	4	7	13	52	16	8	7	3	2
9	6	8	1	1	8	27	55	19	4	3	6	8
8	7	3	3	5	14	43	49	5	10	10	3	7
7	6	12	10	11	44	44	28	4	4	2	12	12
6	34	32	37	25	106	29	10	4	19	13	27	25
5	6	8	8	3	24	24	17	5	11	14	10	10
4	101	101	36	15	55	15	9	15	7	5	72	10
3	48	40	4	1	9	4	5	4	2	1	26	11
2	14	7	..	..	..	..	..	1	1	..	4	12
1	1	1										1

but they seem to be sufficient for conveying an impression of the maturity. The principal drawback of this method of investigation is that we cannot with certainty distinguish between recently spent fish and immature fish. So we must be satisfied with determining the ingestion of food in herring with undeveloped genital organs and during the growth of the latter until the spawning sets in. During the investigation it became apparent that the breadth of the genital organs in both sexes showed a nearly parallel development, and so the measures of both sexes have been combined in the following account.

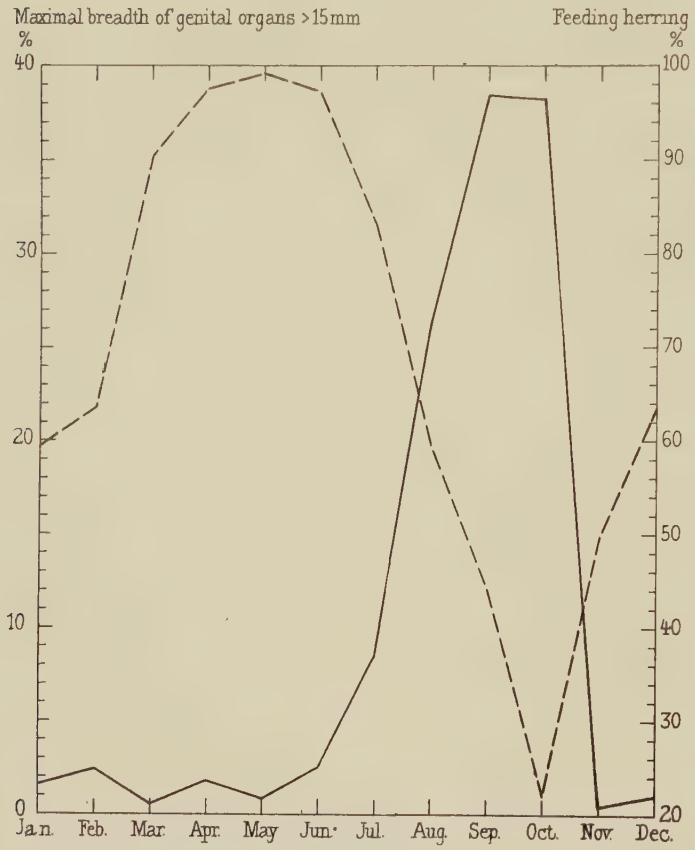

Figure 5. Relative quantity of feeding herring (— — —) and relative quantity of herring with a breadth of genital organs of > 15 mm. (———) in the various months.

For the purpose of getting as large a material as possible — in several cases the genital organs were in such a state, that exact measurings were rendered impossible — we have combined the whole of the material without distinction of the various years. So Table 4 (p. 9) gives the monthly numbers of herring with a breadth of genital organs ranging between 1 and 27 mm.

The range of variation within the separate months being very considerable a calculation of the average breadth per month is of little value; in the table, therefore, we have contented ourselves with bracketing the measures containing at least 5 % of the total number of herring examined in the respective months. It appears from this that in most herring examined between January and May the breadth of the genital organs ranges between 3 and 7 mm., these herring being consequently immature, but after this time we find a distinct growth of the breadth of these organs. In the greater part (i. e. > 5 %) of the herring examined during the following months the breadth of the genital organs ranges within the following limits: June 5—9, July 7—13, August 9—16, September 12—18, and October 15—20 mm. There is hardly any doubt that this gradual rise in the breadth of the genital organs represents a direct development of the immature herring from the time between January and May. But already in August there are indications that besides the said maximum between 9 and 16 mm. a comparatively large number of herring is about to appear, showing the small breadth of 4 mm. in the genital organs, but constituting as yet only 5.5 % of the total number of herring examined. In the months of September—December, however, this quantity of immature (and spent) herring increases considerably, so that we find a number of at least 5 % of the herring examined with a breadth of the genital organs ranging between about 3 and 8 mm. in the intermediate months. This is no doubt due

to the fact that, besides some immature herring still found in the autumn months, we now get an abundance of spent herring, i. e. fish that have spawned in August, September, and October. Thus, judging by these investigations, the herring appearing in November and December are practically exclusively fish with comparatively undeveloped genital organs, a fact corresponding fairly well to the conditions during the rest of the winter until well into the spring.

It appears from what was said above that at any rate by far the greater part of the herring at the east coast of Bornholm will spawn in autumn, in the months of September and October, but most probably some spawning also takes place already in August.

As a further illustration of the said facts we may calculate the comparative number of herring with highly developed genital organs (maximal breadth > 15 mm.), thus getting the following comparative quantities:

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1.7	2.4	0.5	1.8	0.9	2.5	8.5	**26.4**	**38.4**	**38.3**	0.4	0.7

Also from this survey it appears that August, September, and October are the only months in which we find a fairly numerous representation of herring with highly developed genital organs, i. e. herring that are either spawning or very near the beginning of spawning. In Figure 5 are drawn two graphs, one of which represents the relative number of herring with highly developed genital organs (breadth > 15 mm.), the other showing the comparative quantities of feeding herring in the various months.

It appears most clearly from these graphs that in the very months of autumn in which herring with highly developed genital organs are comparatively numerous we find a rapid fall of the relative quantity of feeding herring.

If we now look at the principal spawning period, the months of September and October, and examine the relative number of feeding fish among herring showing different stages of development by their genital organs, we get the following survey, in which the breadths of the genital organs are given in mm. and tabulated in different size groups.

Maximal breadth of genital organs	Numbers feeding	Numbers not feeding	Percentages of feeding herring
1—4 mm.	5	5	50.0 %
5—9 —	35	53	39.8 -
10—14 —	29	41	41.4 -
15—19 —	17	70	19.5 -
>20 —	2	16	11.1 -

These figures show that the largest number of feeding herring, about 40 to 50 %, is found in fish in which the breadth of the genital organs ranges between 1 and 14 mm., the percentage of full and spawning herring (breadth of genital organs > 20 mm.) being only 11.1.

This state of things seems to indicate that the comparatively scanty occurrence of feeding herring in the months of August, September, and October must be put down to the fact that the herring spawning in autumn in the waters east of Bornholm feed only sparsely immediately before and during the spawning period.

Previous publications bring comparisons between the development of the genital organs and the relative numbers of herring with stomach contents from other localities of Danish waters (Jespersen, 1928, p. 112), and so it will be of interest to compare these investigations

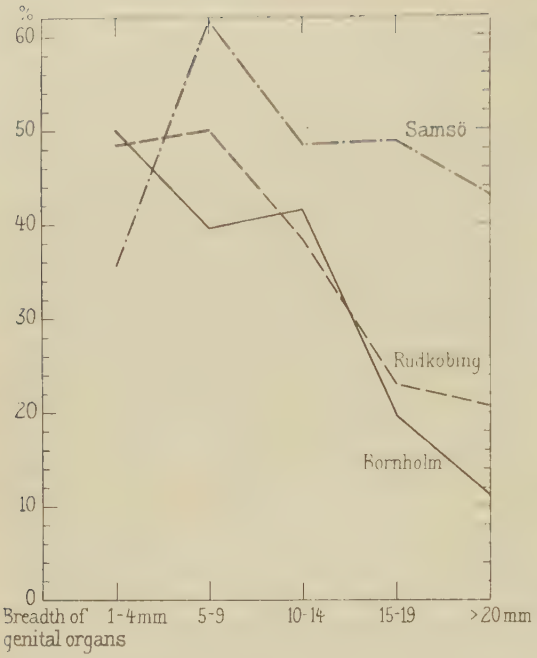

Figure 6. Relative quantity of feeding herring as compared to the development of the genital organs (in September and October) in herring from Samsø, Rudkøbing, and Bornholm.

with the result arrived at in the case of the Bornholm herring. The said investigations deal with autumn-spawning herring from Rudkøbing and Samsø, and in Figure 6 are drawn the graphs for these two localities and for Bornholm.

On the whole the graphs of the Rudkøbing herring and the Bornholm herring show the same course, but as far as the full and the spawning herring (breadth of genital organs > 20 mm.) are concerned 20.6 % of the Rudkøbing herring but only 11.1 % of the Bornholm herring were found to be feeding. A comparison of these figures with those of the Samsø herring shows a very poor agreement, the full and spawning herring of the latter locality showing a feeding percentage of 43.1. In this connexion it is interesting to learn that in a sample of herring spawning in autumn in the eastern Kattegat (Groves Flak) only 5.1 % of full and spawning herring were found to have stomach contents (JESPERSEN, l. c.).

If we sum up the facts mentioned above, we see that different races of herring spawning in autumn in Danish waters feed to a rather different degree during and immediately before the spawning. In September—October feeding herring were found in the following comparative frequencies at different localities of Danish waters:

Groves Flak, eastern Kattegat	5.1 %	Rudkøbing, southern Belt Sea	20.6 %
Samsø, southern Kattegat	43.1 %	East coast of Bornholm	11.1 %

V. Plankton Samples from the Waters East of Bornholm.

As already mentioned no plankton samples were collected simultaneously with the herring chosen for the stomach analyses, but at some few stations along the east coast of Bornholm "Japetus Steenstrup", at that time the research vessel of the Danish Biological Station, collected some plankton samples in the months of July (17—VII—1932) and August (29—30—VIII—1931). From these samples you may get an idea of the composition of the plankton in summer, and so the amounts of the different plankton organisms in the respective samples are stated below. The stations at which the plankton samples were collected are marked down on the map, Figure 1, on p. 3, the positions of the stations being the following:

St. 2972, 29—VIII—1931	Lat. 55° 4′30″ N. —	Long. 15°12′30″ E.	Depth 70 m.
- 2973, 30—VIII—1931	— 55° 6′50″ N. —	— 15°12′25″ E.	— 66 m.
St. 3374, 17—VII —1932	Lat. 55° 4′ 0″ N. —	Long. 15°12′50″ E.	Depth 73 m.
- 3375, - — —	— 55°10′35″ N. —	— 15°07′30″ E.	— 51 m.
- 3376, - — —	— 55°16′00″ N. —	— 14°52′20″ E.	— 53 m.

At first we will look at the plankton samples from the middle of July (Sts. 3374–3376). At each of these three places were made two vertical hauls with the Hensen Net, one from 10 m. to the surface and another from bottom to surface. The counting of the organisms yielded the following result:

Table 5.

Plankton samples from the middle of July (17.–VII.–1932)

Station No.	3374	3375	3376	3374	3375	3376
Depth in m.	25	10	5	26	22	21
Limacina retroversa	160	—	—	1,240	—	—
Centropages hamatus	250	420	190	1,360	2,760	3,010
Eurytemora hirundoides	690	620	130	1,360	550	1,290
Temora longicornis	160	210	200	5,580	6,070	5,590
Acartia tonsa	3,320	6,860	3,380	29,700	28,700	18,820
Acartia longiremis	300	160	—	14,260	12,700	6,020
Evadne Nordmanni	1,370	2,180	1,300	6,200	4,420	5,590
Podon sp.	160	210	190	1,240	—	430
Pseudocalanus minutus	—	—	400	—	—	2,150
Young Lamellibranchs	80	—	—	—	—	—

It will be noticed that the copepod *Acartia tonsa* is by far the most numerous organism. Also the near related species *Acartia longiremis* was found in considerable numbers, but, in contrast to the former species, in comparatively small numbers in the upper water layers. The copepods *Temora longicornis*, *Centropages hamatus*, and *Eurytemora hirundoides* occur in

Table 6.

Plankton samples from the end of August (29/30.–VIII.–1931)

	15–0 m.		25–0 m.		65–0 m.	
Station No.	2972	2973	2972	2973	2972	2973
Depth in m.	6	12	14	14	18	25
Limacina retroversa	—	—	—	170	3,370	5,620
Centropages hamatus	310	140	220	170	380	430
Eurytemora hirundoides	1,250	970	1,120	1,850	1,500	4,750
Temora longicornis		140	450	—	750	430
Acartia tonsa	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Acartia longiremis	—	—	220	340	3,380	4,750
Evadne Nordmanni	2,130	2,220	4,030	1,850	3,000	3,870
Podon sp.	[illegible]	[illegible]	[illegible]	[illegible]	1,500	—
Pseudocalanus minutus	2,340	1,810	3,140	3,020	7,500	3,440
Young Lamellibranchs	780	830	—	830	370	1,730

rather considerable quantities although in much smaller numbers than the *Acartia* species, which together make up about 50—75 % of the total number of organisms. Among the cladocerans *Evadne Nordmanni* predominates, especially in the upper water layers (10—0 m.) where this organism constitutes 21—29 % of the total number of organisms.

By means of Table 6 the contents of the plankton samples collected in the end of August (Sts. 2972—73) may be compared with the above mentioned plankton samples. At each of the two stations three vertical hauls were made with the Hensen Net, from 15, 25, and 65 metres depth to the surface.

Here, too, *Acartia bifilosa* is by far the most numerous species, and it appears even more distinctly than from the July samples that *Acartia longiremis* is a species occurring comparatively deep in the water, at depths of more than 25 m below the surface. For the rest the same copepods occur in August as in July, but if we compare the quantities of different organisms in the hauls from bottom to surface, it is clear that most species are far more numerous in July than in August. However, a rather characteristic feature is that *Pseudocalanus elongatus*, which seems to prefer the deeper water layers, proved to occur in far larger numbers in the latter of the two months. Among the cladocerans *Evadne Nordmanni* still plays a prominent part, but furthermore the August samples — unlike the samples from the middle of July — contain rather considerable quantities of *Bosmina maritima*. Finally, it is worth noting that the plankton samples from August show a far richer representation of young lamellibranchs than those from July.

Table 7.

The relative quantity of the different plankton organisms in plankton samples from July and August.

	St. 3374 $^{17}/_{7}$ 32		St. 2972 $^{29}/_{8}$ 31	
	10—0 m.	Bottom—0 m.	15—0 m.	Bottom—0 m.
Pseudocalanus elongatus	2	2	—	9
Centropages hamatus	3	3	2	1
Eurytemora hirundoides	12	3	8	4
Temora longicornis	2	9	—	2
Acartia bifilosa	49	48	56	42
Acartia longiremis	5	23	—	9
Evadne Nordmanni	24	10	14	8
Podon sp.	2	2	—	4
Bosmina maritima	—	—	15	20
Young Lamellibranchs	1	—	5	1

Two of the stations from July and August, respectively St. 3374 and 2972, being situated very close to each other (see map, Figure 1), it may be of interest to compare the relative quantities of the different organisms from the vertical hauls carried out at these stations in both of the said months (see Table 7).

The most conspicuous difference between the plankton samples of the two months is the far larger comparative quantity of *Bosmina maritima* in the samples from August, 29th, than in those from July, 17th.

In a previous chapter (see pp. 6—7) we have touched on the question of the quantity of plankton and number of copepods as compared to the herring fishery of the two years 1931 and 1932.

VI. The Occurrence of the Different Organisms in the Herring Food.

In the following survey of the importance of the various organisms as food matters of the herring in the waters round Bornholm the standard applied is the relative quantity of feeding herring in which the organisms in question were established to constitute part of the stomach contents. Of course this method does not give any exact expression of the greater or less importance of the various organisms as food matter, their absolute numbers and different nutritive value not being considered. The method applied is only meant to give some indication as to the frequency of the various organisms in the stomach contents of the herring.

All smaller organisms like copepods and cladocerans were not counted, for on account of the preservation and the decomposed state of many of the organisms it was in many cases impossible to carry out even an approximately accurate counting of their numbers. For all larger food organisms, however, more particularly mysids, amphipods, isopods, and young fish, the countings were carried out as accurately as possible; in the case of these animals we are therefore able to state the numerical occurrence in the fish food at the different seasons of the year.

1. Copepoda.

In a quantitative respect the copepods are in most cases the principal food organism of the herring at Bornholm. However, their importance as a food matter varies with the different seasons, the summer being the period of their particular predominance over the different elements of the herring food. This variation is illustrated by Table 8, in which are put down the monthly percentages of herring with copepods as food.

Table 8.

Monthly percentages of feeding herring with copepods as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	100.0	95.0	100.0	94.1	90.5	82.4
1933.....	94.2	96.1	98.2	100.0	100.0	98.7	100.0	98.1	100.0	100.0	83.6	82.1
1934.....	88.2	79.1	100.0	..	100.0	100.0	100.0	74.3	60.5	70.8	83.3	76.2
1935.....	64.0	93.7	97.5	96.6	100.0	100.0	97.8	96.1	94.2	100.0	95.8	88.1
Mean...	82.1	89.6	98.6	98.3	100.0	99.6	99.4	90.9	88.7	91 2	88.3	82.2

It will be seen that between March and July (inclusive) copepods were found as food in a very large number of fish, occurring in 95—100 % of the herring examined. In autumn the quantities decrease, and in the winter months December and January a minimum occurs. This variation of the monthly percentages appears most clearly from the graphic representation in Figure 7.

The fluctuations in the occurrence of the copepods as herring food established at different seasons of the year must no doubt be put down to the herring at certain seasons preferring

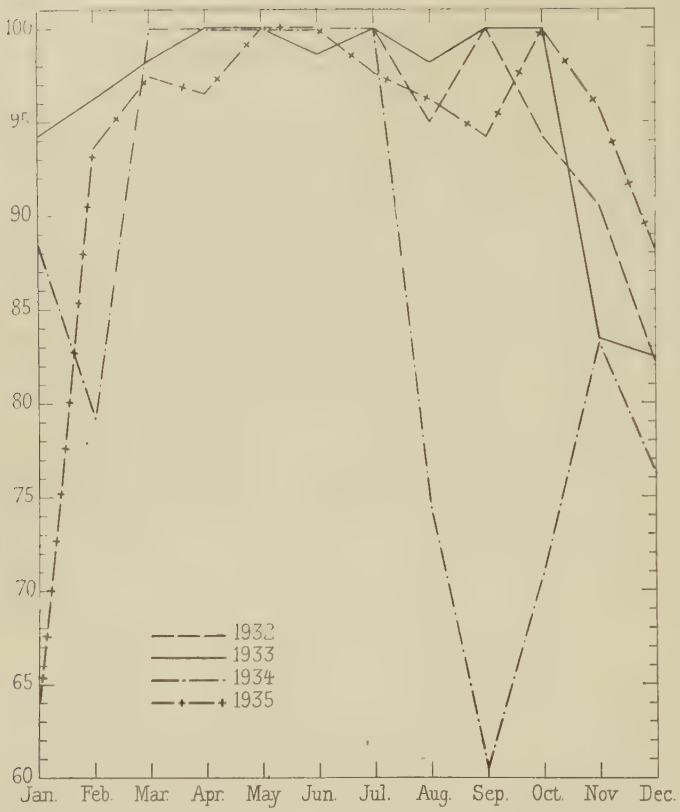

Figure 7. Monthly percentages of feeding herring with copepods as food in the years 1932, 1933, 1934 and 1935.

other and, generally speaking, larger organisms than copepods for their food, but it should also be remembered, as already mentioned, that on the whole the feeding activity of the herring falls off most rapidly in autumn, more particularly in September and October. In autumn and winter the herring lives on larger crustaceans, particularly mysids, to a far higher degree than in summer, and during the first months of the year it feeds principally on young fish.

Pseudocalanus elongatus (Boeck).

This species is one of the copepods being of the greatest importance as herring food in the waters at Bornholm, but an occurrence in the stomach contents in so considerable quantities, that the species could be of quantitative importance as a food matter was established only at certain seasons.

It appears from the Table 9 that by far the largest number of herring containing this species is found during the first half of the year, but during the second half, more particularly between August and December (inclusive) the species was found as food in comparatively few herring. If we examine the quantities represented by *Pseudocalanus* in the herring food, we find it to be the predominant copepod species especially in the months of April, May, and June, which corresponds fairly well to the season in which it was established as food in the greatest number of herring.

Table 9.

Monthly percentages of feeding herring with *Pseudocalanus elongatus* as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	15.8	6.7	1.8	5.0	6.7	26.9
1933.....	90.1	25.5	86.0	53.2	64.8	—	5.3	3.4	—	—	10.0	—
1934.....	32.3	90.5	100.0	..	98.3	53.1	84.5	61.1	9.1	20.0	40.0	—
1935.....	28.6	55.0	15.8	100.0	100.0	89.0	67.3	50.0	23.1	—	23.8	50.0
Mean...	50.3	57.0	67.3	76.6	87.7	47.4	43.2	30.3	8.5	6.2	20.1	19.2

Centropages hamatus Liljeborg.

Although this species was found as herring food during all months of the year, it plays only an inferior part as a food matter, the quantities established being always comparatively small. As will appear from Table 10 it is rather distinctly a summer form, the period from April to August (inclusive) being the only season during which it was found as food in a comparatively large number of herring.

Table 10.

Monthly percentages of feeding herring with *Centropages hamatus* as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	4.0	—	1.8	15.0	9.5	1.5
1933.....	—	6.4	1.0	59.6	98.3	3.9	18.4	20.3	—			
1934.....	6.5	4.8	4.8	..	22.0	18.7	27.4	16.7	9.1	20.0	—	—
1935.....	—	—	21.1	—	9.8	15.4	36.7	30.0	7.7	—	28.6	3.3
Mean...	2.2	3.7	9.0	29.8	43.4	12.7	21.6	16.7	4.6	8.7	9.5	1.2

During the winter half-year this species is very poorly represented in the herring food, and even in summer it generally occurs in small quantities as compared with the other copepods. Its highest relative numbers in the herring food seem to be found from the end of April to the beginning of June, and plankton samples from the middle of July showed much higher numbers than samples from the end of August (see Tables 5 and 6 on p. 13).

Limnocalanus grimaldi (de Guerne).

In the Baltic this species must be considered a marine-glacial relict, the primitive form of which is now only found in some river outfalls of the Arctic Ocean. During the stomach analyses of herring from the east coast of Bornholm one specimen (♀ ad.) was found on May 11th, 1933, in a herring caught in drift-net 4 nautical miles N. of Gudhjem. The species is common in the northern parts of the Baltic, its southern limit of normal distribution being approximately the ridge which separates the central basin of the middle Baltic from the Bornholm Basin (Hessle & Vallin 1934, p. 30), but stray specimens may be found farther southwards (see *i. a.* Ekman, 1914, and Mielck & Künne, 1935).

Temora longicornis O. F. Müller and *Eurytemora hirundoides* Nordqvist.

During the stomach analyses it was often impossible to distinguish between the two species *Temora longicornis* and *Eurytemora hirundoides*, and so it became necessary to treat the two species as one. Taken as a whole throughout the year they are undoubtedly the most important copepod species in the food of the Bornholm herring. Especially during the winter half-year they abound in the herring food, but also during the rest of the year their quantities are rather considerable although several samples from the time between May and August (inclusive) contain just as large or even larger quantities of other copepod species. In Table 11 below are given the monthly percentages of feeding herring with the two copepod species as food, and it appears from the mean figures that in 10 months of the year the percentages range

between about 87 and 97. In both of the months April and May the average percentages are as low as 70—72, but if we look at the quantities of the different years, we see that these low mean figures are due to the fact that in one year, 1935, comparatively few herring were found to contain the two copepod species in the months of April and May. No doubt this one year may be considered an extraordinary case, so that it is quite an exception that relatively few herring are found with the said copepods as food.

Table 11.

Monthly percentages of feeding herring with *Temora longicornis* and *Eurytemora hirundoides* as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	91.1	100.0	96.4	85.0	89.5	98.5
1933.....	100.0	91.5	97.0	97.9	99.4	80.4	100.0	94.9	100.0	100.0	70.0	94.7
1934.....	93.5	90.5	80.9	..	98.3	98.4	98.8	88.9	63.3	80.0	95.0	80.0
1935.....	100.0	90.0	100.0	45.5	13.0	100.0	89.8	90.0	100.0	100.0	95.2	96.7
Mean...	97.8	90.7	92.6	71.7	70.2	92.9	94.9	93.4	89.9	91.2	87.4	92.5

As mentioned the stomach analyses proved it to be impossible to distinguish between the two species, but there is no doubt that *Temora longicornis* occurs more regularly all the year round whereas *Eurytemora hirundoides* is more particularly a summer and autumn form and plays quite an inferior part at other seasons. This agrees well with Swedish plankton investigations (Hessle & Vallin, 1934). In some few samples of herring the quantities of the species *Eurytemora hirundoides* were very large: in a sample from July 19th, 1935, this species constituted about 90 % of the total number of *Temora* and *Eurytemora* found in the stomach contents of the herring. The two authors mentioned above report (*l. c.* p. 34) on the distribution of *Eurytemora hirundoides* in the Baltic that the species reaches its highest development in the Botten Sea, the Sea of Åland and in the coastal basins of the Middle Baltic, decreasing in importance partly towards the central and southern parts of the Baltic, partly towards the northern part of the Botten Bay. However, it is proved by the plankton analyses given in Tables 5 and 6 (p. 13) and by the stomach analyses in hand that rather considerable quantities of the species may be found as far southwards as in the waters east of Bornholm, where it is sometimes a rather important item in the food of the herring.

Acartia bifilosa (Giesbrecht) and *Acartia longiremis* (Liljeborg).

Of the genus *Acartia* these two species were established in the stomach contents of the herring, but in the stomach analyses it was impossible to maintain a distinction of species, and so the two species are treated as one in the following. The relative quantity of herring in which the genus *Acartia* was found as food will appear from the following Table 12.

In the months of February, March, and April *Acartia* was found as food in a rather small number of herring, in the summer months in the largest comparative number, and late in autumn and in winter until the month of January (inclusive) the genus *Acartia* occurs as food matter, although in a somewhat decreasing degree, in a relatively large part of the herring examined.

Table 12.

Monthly percentages of feeding herring with *Acartia* sp. as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	79.2	60.0	49.1	75.0	57.1	71.6
1933.....	94.5	29.8	73.0	57.4	100.0	98.0	89.5	74.6	83.3	50.0	60.0	42.1
1934.....	87.1	9.5	—	..	84.7	92.2	86.9	75.0	68.2	80.0	65.0	60.0
1935.....	14.3	35.0	34.2	45.5	22.8	48.4	81.6	80.0	23.1	—	95.2	76.7
Mean...	65.3	24.8	35.7	51.4	69.2	79.5	84.3	72.4	55.9	51.2	69.3	62.6

An examination of the quantities of the genus *Acartia* in the food as compared with other copepods shows us that this genus was found to predominate only in the months of May, June, July, and partly August, but during the rest of the year the amounts established were comparatively small. In some samples the species were determined as far as possible, and in most cases *Acartia bifilosa* turned out to be somewhat more numerous in the herring food than *Acartia longiremis*, the latter, however, often occurring in fair numbers. So the stomach analyses available cannot be used as a basis of establishing positive variations in the proportionate quantities of the two species in the herring food.

The few plankton samples taken at the east coast of Bornholm show a large numerical preponderance of *Acartia bifilosa*, but at the same time it appears distinctly from the investigations that *Acartia longiremis* is comparatively more numerous in the deeper water layers. In Table 13 below are given the relative quantities of the two species in various water layers, established by collectings in the middle of July and the end of August.

Table 13.

Relative quantities of *Acartia bifilosa* and *Acartia longiremis* in plankton samples from the middle of July and the end of August.

		10—0 m.	15—0 m.	25—0 m.	Bottom—0m.
July, 17th	*A. bifilosa*	96.6 %	..	..	70.1 %
	A. longiremis	3.4 -	..	..	29.9 -
August, 29th—30th	*A. bifilosa*	..	100.0 %	97.4 %	80.7 -
	A. longiremis	..	0.0 -	2.6 -	19.3 -

It appears quite distinctly from these plankton samples that the number of *Acartia longiremis* increases with the depth whereas *Acartia bifilosa* is more particularly an inhabitant of the surface region.

A nearly corresponding vertical distribution of the two species was found during Swedish plankton investigations in the Bornholm Basin (Hessle & Vallin, 1934, p. 36). Investigations were carried out in May and July, and it seems to appear that the two species were nearly equally numerous in the upper water layers (down to a depth of 15—30 m.), but at greater depths (30—100 m.) the specimens occurring belonged nearly exclusively to the species *Acartia longiremis*.

Oithona similis Claus.

Only very few individuals of this species were found in the herring food, and so it is no doubt of quite inferior importance as a food matter. During the Danish collcetings of plankton the species was not observed, but according to Hessle & Vallin (*l. c.*, p. 38) it is rather numerous in the deep water of the Bornholm Basin, i. e. from the bottom and at least up to a depth of about 50 m.

Concluding Remarks on the Importance of the Copepods as Herring Food.

The relative quantities of feeding herring with the different copepods as food being rather illustrative of the greater or less importance of the various copepod species in the diet of the herring, Figure 8 brings a graphical representation of the comparative numbers of feeding herring with the chief copepod species in their stomach contents. The graphs are drawn on the basis of the monthly mean figures of the respective species calculated in Tables 9—12 and include the material from the years 1932—35.

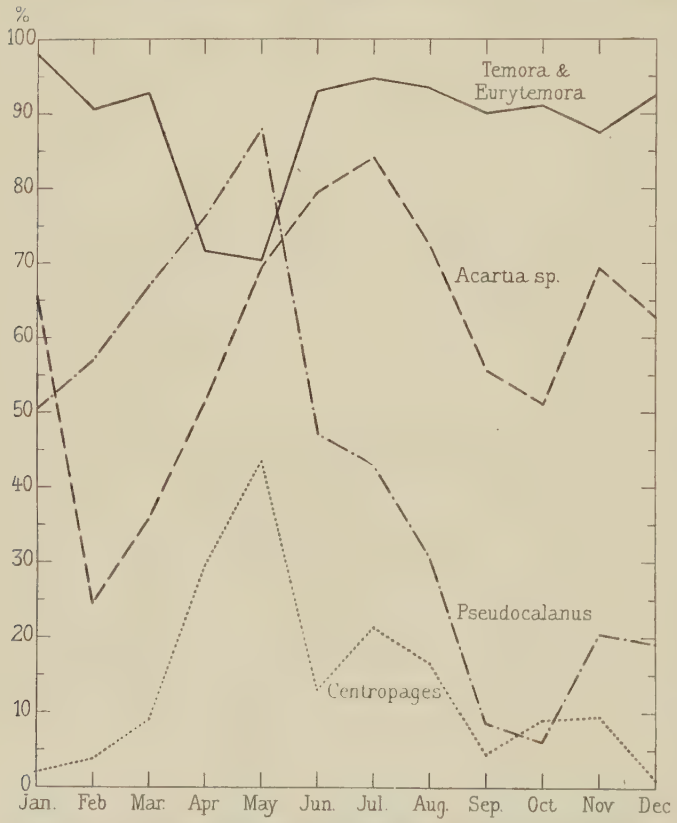

Figure 8. Average monthly percentages of herring with the chief copepod species as food.

Temora longicornis and *Eurytemora hirundoides* together constitute the copepod species generally found as food in the largest number of herring. As already mentioned the rather low percentages of April and May are due to the fact that in one year (1935) remarkably few herring were found to have fed on these copepods, and so these figures should undoubtedly be put down to extraordinary conditions. The genus *Acartia* (with the species *A. bifilosa* and *A. longiremis*) occurs principally in summer, decreases in number late in autumn and in winter, and shows a distinct minimum in February—March. These species were the predominant copepods of the herring food between May and August (inclusive). *Pseudocalanus elongatus* was met with in a large number of herring ($> 50\,\%$) between February and May, and especially in the months of April, May, and June it is the predominant species. In comparison with the copepods mentioned above *Centropages hamatus* is of inferior importance as a food matter of the herring. Especially in summer it was found as food in a comparatively large number of herring, but the absolute numbers of the species were always relatively small.

2. Cladocera.

The importance as herring food of the cladocerans as a whole is restricted to the summer half-year or rather to the time between May and October (inclusive) as will appear from Table 14, which gives the monthly percentages of herring with cladocerans as food.

Table 14.

Monthly percentages of feeding herring with cladocerans as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	37.5	25.0	54.5	64.7	3.6	—
1933.....	—	—	—	4.3	69.8	85.9	47.2	45.3	36.5	20.0	3.7	—
1934.....	—	—	—	..	78.5	88.5	80.3	57.8	62.2	37.5	3.3	—
1935.....	—	—	7.1	—	10.4	89.7	36.3	41.3	65.2	50.0	8.7	9.1
Mean...	—	—	2.4	2.1	52.9	88.0	50.3	42.3	54.6	43.0	4.8	2.3

This state of things appears even more distinctly from Figure 9, in which the relative average quantities per month are shown graphically for the respective years 1932—35. It will be noticed that in all three years 1933, 1934, and 1935 there is a very sudden rise of the relative numbers of herring with cladocerans as food from April to May and that the month of June shows a distinct maximum. After this time there is a falling off of the percentages, but on the whole another small rise occurs in the months of September and October. As will appear from the following this rise in late summer and autumn is due to a difference in the occurrence of the various cladocerans in the summer months and in autumn. It is a conspicuous feature that no cladocerans at all was found as food of the herring in January and February, and altogether they play quite an inferior part as a food matter in winter from November to April (inclusive).

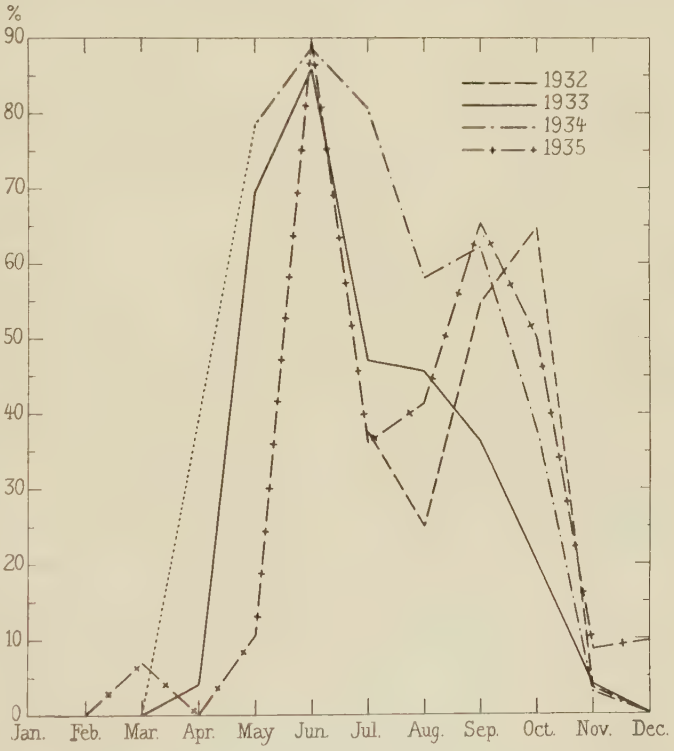

Figure 9. Monthly percentages of feeding herring with cladocerans as food in the years 1932, 33, 34, and 35.

Evadne Nordmanni Lovén.

Like the rest of the cladocerans this species is a summer form: during the present investigation it was found as herring food only from April to October (inclusive) as will be seen from the following table.

The largest numbers of herring feeding on this species are found in May, June, and July,

Table 15.

Monthly percentages of feeding herring with *Evadne Nordmanni* as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	..	..	4.6	5.9		
1933.....				5.4	66.6	85.9	30.9	14.4	2.8	—	—	
1934.....				..	78.5	84.3	46.4	12.5	20.1	12.5		
1935.....					8.3	62.4	3.5	11.5	20.0	16.6		
Mean...				2.7	51.1	77.5	26.9	12.8	11.9	8.7	—	—

the same months in which its highest numerical strength occurs in the herring food: it is characterized by the frequency + or c only in the time between May, 17th, and July, 3rd. Outside this time the quantities occurring in the herring examined correspond to the frequency degrees r or rr. Thus, even to a higher degree than the rest of the cladocerans, *Evadne Nordmanni* is distinctly a summer form. Many of the *Evadne* found in the herring stomachs in May and a few found in June were observed to contain youngs.

In the few plankton samples collected in the water east of Bornholm in the middle of June and the end of August (see Table 7 on p. 14) *Evadne Nordmanni* occurs in fair numbers. In the middle of July it constitutes 24 % of the total number of organisms in the upper water layers (10—0 m.) and 10 % in hauls from bottom to surface. As late as the last days of August the species makes up 14 % in the upper water layers and 8 % in plankton hauls from bottom to surface, and so it is rather surprising to find the herring food of this season containing the comparatively small quantities mentioned above.

Podon sp.

The different species of the genus *Podon* in the stomach contents being difficult to determine, all individuals belonging to this genus are taken together in the calculations below. In the few cases in which a determination could be carried out the individuals belonged to the two species *Podon polyphemoides* (Leuckart) and *P. intermedius* Liljeborg, but most probably the species *P. leuckarti* G. O. Sars, which is rather common in the Baltic, is also found in the present material. As will appear from table 16 the genus *Podon* was found as food in the largest number of herring between May and August, during which period the quantities averaged at least 25 % of the herring examined.

Table 16.

Monthly percentages of feeding herring with *Podon sp.* as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	..	..	1.1	5.9	0.8	—
1933.....	—	—	—	—	38.4	41.0	22.4	30.6	7.7	—	3.7	—
1934.....	—	—	—	..	67.5	64.3	52.0	23.1	11.5	8.3	3.3	—
1935.....	—	—	7.1	—	3.5	89.7	26.9	22.0	10.8	—	5.8	9.1
Mean...	—	—	2.4	—	36.5	65.0	33.7	25.2	7.8	3.5	3.4	2.3

With the exception of the period between May and August mentioned above *Podon* was found as food in a comparatively small number of herring, and in the material from January, February, and April the genus was not established at all in the herring food. If we examine the numerical strength of the genus *Podon* in the stomach contents of the herring, we find that the only time in which its relative frequency in the samples could be characterized by + or c is the period between May, 17th, and August, 24th, which corresponds very well to the months in which a comparatively large number of herring was reported to have fed on Podon.

In the plankton samples from the water east of Bornholm (see Table 7, p. 14) the genus *Podon* constitutes a relatively small amount of the total number of organisms: in July it makes up only 2 % of the total number of organisms in the upper water layers as well as in plankton hauls from bottom to surface, and in August only 4 % in plankton samples taken in vertical hauls from bottom to surface.

Bosmina maritima P. E. Müller.

The cladocerans mentioned above were rather distinctly summer forms, but the species *Bosmina maritima* shows its maximum occurrence in late summer and autumn. As a matter of fact its greatest quantities in the herring food are also found at this season. As will appear from Table 17 the species was established as food in the largest numbers of herring in the months of August, September, and October.

Table 17.

Monthly percentages of feeding herring with *Bosmina maritima* as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	..	..	51.1	61.8	2.3	—
1933.....	—	—	—	—	1.2	2.4	2.6	36.1	28.8	20.0	—	—
1934.....	—	—	—	..	—	—	15.2	54.6	55.5	16.6	—	—
1935.....	—	—	—	—	—	—	—	28.3	51.9	33.3	8.7	—
Mean...	—	—	—	—	0.4	0.8	5.9	39.7	46.8	32.9	2.7	—

Within the three months mentioned this cladoceran was in several cases found in so large quantities in the stomach contents of the herring, that the numbers by far surpassed those of all other organisms. As an illustration of the enormous quantities in which this species sometimes occurs in the herring food may be mentioned that the stomach of one herring caught on August 6th, 1934, contained no less than about 58,400 individuals of *Bosmina*; the stomach contents consisted nearly exclusively of this cladoceran.

An examination of the numerical strength in the stomach contents of the herring shows us that the frequency of *Bosmina maritima* may be characterized by + and c or cc only in the time between August, 6th, and September, 20th, and it appears from this that August and September are in fact the only months in which this cladoceran is of real importance as a food matter of the Bornholm herring.

In the Danish plankton samples collected in July and August *Bosmina* occurs most scantily in the samples from the middle of July, but is numerous in samples from the last days

of August. We have already mentioned the two stations E. of Nekso, situated very close to each other (see Table 7, p. 14): here *Bosmina* did not occur at all in the samples from the middle of July, but in the end of August it constituted 15 % of the total number of organisms in the upper water layers (15 –0 m.) and 20 % of the total number of organisms in vertical hauls from bottom to surface. This is a very distinct proof that a rapid production of this species has taken place during the time between the middle of July and the end of August.

The results stated above agree well with the investigations carried out by Hessle & Vallin (*l. c.*, p. 41) concerning the distribution of *Bosmina maritima* in the Baltic. During the Swedish investigations the species was not observed outside the period between May and October, the maximum production occurring principally in the months of July –September.

Concluding Remarks on the Importance of the Cladocerans as Herring Food.

The importance of the cladocerans as herring food is confined to the warm season, the only time in which they were found as food in a considerable number of the herring examined being the period between May and October (inclusive). In Figure 10 are represented the relative quantities of herring with the various cladocerans as food, and the average sizes given are the monthly mean numbers put down in Tables 15—17 for the total material of the years 1932—35.

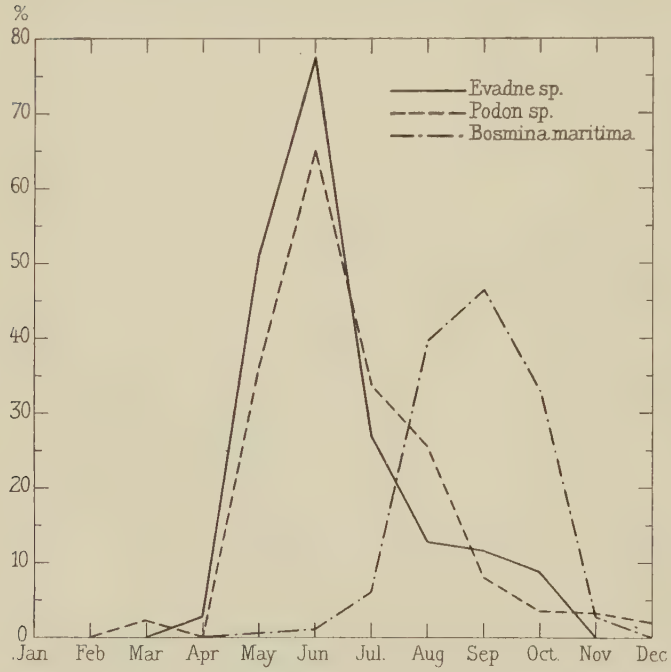

Figure 10. Average monthly percentages of herring with the various cladocerans as food.

Both *Evadne Nordmanni* and the genus *Podon* show a maximum occurrence in the herring food in June, the relative quantities of herring with these cladocerans decreasing smoothly in the autumn. On the whole there is a remarkable correspondence between the graphs of respectively *Evadne* and *Podon* shown in Figure 10. In contrast to the comparatively small number of herring feeding on *Evadne Nordmanni* and the genus *Podon* in autumn we find, especially in the months of August, September and October, *Bosmia maritima* as food in quite a considerable number of the herring examined. In other words: among the cladocerans *Evadne* and *Podon* are important as herring food in summer, *Bosmina* playing a prominent part as food matter of the autumn.

3. Ostracoda.

Small numbers of ostracods were found in quite a few herring stomachs, but an identification of species was impossible.

4. Cirripedia.

Larval stages of cirripedes were found several times in the herring food, but always in extremely small numbers. Cirripede nauplii were observed only in one herring (7—V—35) and very sparsely at that, whereas cypris stages were found in several cases, but always in extremely small numbers. Cypris stages seem to reach their highest frequency in May though they were met with in the food of 12 herring samples between January, 27th, and June, 11th, thus occurring exclusively during the first half of the year.

5. Mysidacea.

More especially in winter the mysids are very important as food of the Bornholm herring. Their quantities in the stomach contents are rarely very large, but on account of their fairly considerable size these animals play a prominent part in the diet of the herring. The relative quantities of herring with mysids as food in the different months are given in Table 18, and the monthly average figures are shown graphically in Figure 11.

Table 18.

Monthly percentages of feeding herring with mysids as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	3.0	15.0	2.5	8.8	29.4	44.4
1933.....	13.1	31.5	7.3	—	0.7	—	3.4	2.8	6.6	—	10.3	21.6
1934.....	24.6	22.5	18.2	..	2.5	—	1.0	9.2	19.1	16.6	20.0	71.4
1935.....	50.8	14.1	2.5	3.4	3.8	—	11.0	3.8	16.7	8.3	7.1	30.9
Mean...	29.5	22.7	9.3	1.7	2.3	—	4.6	7.7	11.2	8.4	16.7	42.1

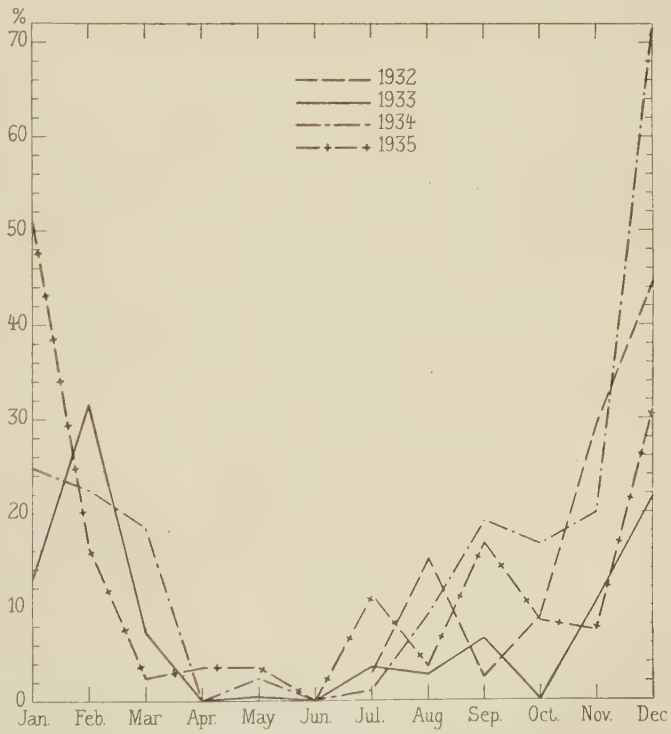

Figure 11. Monthly percentages of feeding herring with mysids as food in the years 1932, 33, 34, and 35.

It appears most distinctly from Figure 11 that by far the largest numbers of herring feeding on mysids occur in the months of November, December, January, and February, but also in autumn we sometimes find mysids in the stomach contents of a rather large percentage of the herring examined.

The variation established in the relative quantity of herring with mysids as food at different seasons appears even more distinctly if we use the total material from the years 1932—35 for a calculation per month of the average number of mysids found as food in 100 specimens of feeding herring. Unlike the smaller

organisms, as for instance copepods, the numbers of mysids were counted as accurately as possible during the stomach analyses.

Table 19.

Average quantities of mysids found in the stomachs of 100 feeding herring, calculated per month on the basis of the total material of the respective months.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. of feeding herring	241	206	214	115	443	234	399	216	223	63	337	215
No. of mysids.....	472	279	92	1	34	0	234	38	122	14	512	873
No. of mysids per 100 feeding herring	196	135	43	1	8	0	59	18	55	22	152	406

If we put down the monthly mean figures in a graphical form, we get the curve drawn in Figure 12.

The graph shows a marked rise in the winter half-year, a distinct maximum of the occurrence of mysids in the herring food appearing in December. Thus we find that the largest number of herring found to feed on mysids occurs nearly at the same time as the largest absolute number of mysids in the stomach contents of the herring.

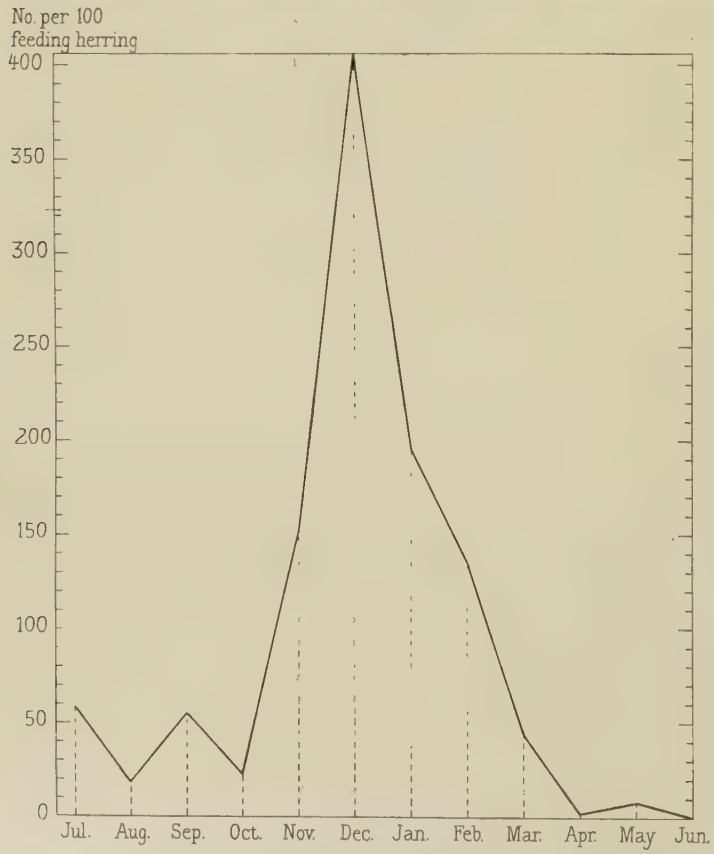

Figure 12. Monthly average numbers of mysids per 100 feeding herring.

In connexion with this question about the maximum occurrence of the mysids in the herring food in winter attention should be called to the fact that also in the Belt Sea, viz. at Rudkøbing on the island of Langeland, mysids were observed in particularly large quantities as herring food in the month of December (Jespersen, 1928, p. 36).

During the stomach analyses only 3 species of mysids could be identified with certainty: *Mysis* (*Michtheimysis*) *mixta* Liljeborg, far predominant in numbers, and *Macropsis* (*Mesopodopsis*) *slabberi* (v. Beneden) and *Praunus* (*Mysis*) *inermis* (Rathke), of which two species only occasional specimens were observed. It is rather surprising that no other species were found in the herring food. A possible explanation of this fact is that the mysids taken by the herring are principally the species living above deeper water; *M. mixta* generally occurs scantily in shallower parts of water.

Mysis mixta Liljeborg.

As already mentioned by far the greater part of the mysids found belongs to this species, and in all essentials the tables and graphical representations given above are representative of the occurrence of this species in the herring food. There is hardly any doubt that, at any rate above fairly deep water, *M. mixta* is the mysid species that occurs in the largest quantities in the water round Bornholm and also in vast areas of the Baltic (see *i. a.* Apstein, 1906, Otterstrøm, 1910, and Hessle & Vallin, 1934). According to Hessle & Vallin (*l. c.* p. 48) the species is not found in shallow water, and the limit of its vertical distribution in an upward direction may be put at about 20 m. below surface. It is worth noting that its maximum representation in the herring food in winter seems to coincide with the spawning season of the species (Apstein, *l. c.*). In most cases the mysids occurring in the herring stomachs were few in number, but sometimes considerable quantities appear: in 7 of the herring examined the numbers ranged between 50 and 60 specimens, and in one herring (31—XII—34) even about 110 specimens were found.

Macropsis slabberi v. Bened.

This species occurred in extremely small numbers in the stomach contents of the herring. The only cases in which it was established with certainty were in 1 herring from 28—II—34 (1 ad.), 2 herring from 10—III—34 (3 juv.), and one herring from 7—V—35 (1 ad.). The number of this species hardly amounts to more than 2 or 3 $^0/_{00}$ of the total quantity of mysids found in the herring stomachs.

Apparently the species was not formerly observed in the waters round Bornholm or the eastern part of the Baltic, but it is known in the Kieler Bay (Möbius, 1873, p. 124) and the Mecklenburg Bay (Mielck & Künne, 1935, p. 71) in the western Baltic, and it is also well-known in the Belt Sea.

Praunus inermis Rathke.

This species was established with certainty in only one herring from 4—XII—33, in the stomach contents of which two specimens occurred. Of the three most common mysids in Danish waters this species is found to go out to the deepest water (Blegvad, 1921, p. 67).

6. Cumacea.

As food of the Bornholm herring the cumacea are generally of inferior importance. This appears from Table 20, which gives the relative quantities of herring feeding on cumacea.

Table 20.

Monthly percentages of feeding herring with cumacea as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	1.2	—	—	—	3.4	11.4
1933.....	2.3	—	—	—	—	—	—	—	—	—	1.8	—
1934.....	—	—	—	..	—	—	—	—	—	—	—	4.8
1935.....	—	—	—	—	—	—	—	—	—	—	1.4	7.1
Mean...	0.8	—	—	—	—	—	0.3	—	—	—	1.6	5.8

Although the quantities of herring feeding on cumacea are comparatively small, it is rather conspicuous that these organisms are nearly exclusively found as part of the herring food in winter with a fairly distinct maximum in November—December.

Diastylis rathkei Kröyer.

This species is the only cumacea established with certainty in the stomach contents of the herring. Apart from 2 herring from 26 XI 32, in the stomachs of which 32 and 35 individuals of this species were observed, all individual herring stomachs contained numbers of less than 10, in most cases only 1 or 2 specimens. The species is no doubt one of the most common cumacea of the Baltic; according to Zimmer (1933, p. 94) it is found from about Lat. 59° N. southwards.

7. Isopoda.

In comparison with many other organisms the isopods constitute a very small part of the herring food, and it also appears from Table 21 that isopods were found as food in a relatively small number of the herring examined. It is worth noting that they were observed in the herring food exclusively during part of the winter half-year, in the time between October and January (inclusive), more particularly in the months of November and December.

Table 21.

Monthly percentages of feeding herring with isopods as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	—	—	—	2.9	—	—
1933.....	1.4	—	—	—	—	—	—	—	—	—	15.0	14.0
1934.....	1.9	—	—	..	—	—	—	—	—	—	—	—
1935.....	—	—	—	—	—	—	—	—	—	—	4.2	2.4
Mean...	1.1	—	—	—	—	—	—	—	—	0.7	4.8	4.1

Idothea sp.

Only the genus *Idothea* was established with certainty in the herring food; however, the great majority of specimens found being young individuals, the determination of species cannot possibly be absolutely reliable. 2 herring (25—XI—33 and 3—I—34) were found to have taken 5 specimens, but otherwise only individual specimens were met with.

8. Amphipoda.

The stomach analyses indicate comparatively small numbers of amphipods only, but like various other food organisms of the herring they seem by preference to appear in the herring food at certain seasons, being nearly totally absent at other times of the year. As will

be seen from Table 22 amphipods were generally found as food in a relatively small number of the herring examined, but no doubt the largest quantities were found during the winter half-year, in the time between October and February (inclusive).

Table 22.

Monthly percentages of feeding herring with amphipods as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	0.6	—	—	14.7	0.4	—
1933.....	—	—	1.8	—	0.7	—	0.9	—	—	—	9.0	20.0
1934.....	9.9	12.7	—	..	—	—	—	1.4	—	—	—	—
1935.....	—	3.2	—	—	—	—	—	—	—	—	4.2	1.5
Mean...	3.3	5.3	0.6	—	0.2	—	0.4	0.3	—	3.7	3.4	5.4

Another illustration of the numbers of amphipods in the herring food bases on the total material of the years 1932—35, from which were calculated the monthly average numbers of amphipods found in the stomach contents per 100 feeding herring as will appear from Table 23.

Table 23.

Average numbers of amphipods found in the stomachs of 100 feeding herring, calculated per month on the basis of the total material of the respective months.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. of feeding herring	241	206	214	115	443	234	399	216	223	63	337	215
No. of amphipods	125	10	2	0	1	0	2	1	0	5	23	27
No. of amphipods per 100 feeding herring	52	5	1	0	0.2	0	0.5	0.5	0	8	7	13

According to this calculation the largest numbers of amphipods, 52 specimens per 100 feeding herring, occur in January; in December we find 13 specimens, and in the months of October, November, and February 5—8 specimens per 100 feeding herring. During the rest of the year no amphipods at all, or at any rate no more than 1 specimen per 100 feeding herring, were observed in the herring food.

Investigations on the food of the herring in other Danish waters have shown that at least in one locality, at Rudkobing on the island of Langeland, the quantities of amphipods are also generally found to be largest in winter, but only in the months of November and December (Jespersen, 1928, p. 39).

Hyperia galba Montagu.

During the analyses of the contents of the herring stomachs this species was found only in one individual, caught on 18—I—35. In the Baltic the species is observed up to the waters round Gotland.

Pontoporeia femorata Kröyer.

This species is common in most places of the Baltic and is said to occur most frequently east of Bornholm (Stephensen, 1928, p. 126). Only one specimen was found in the herring stomachs examined, in a herring caught on 4—XII—33.

Calliopius rathkei (Zaddach).

In the stomach contents of two herring from 4—XII—33 and 3—I—34 were found a few individuals of this species, which is widely distributed over the Baltic.

Gammarus locusta L.

This form, which plays a dominating part in the plankton production in the littoral zone of the whole Baltic, is by far the most numerous of the amphipods found during the stomach analyses. It constitutes in quantity more than 90 % of all amphipods established in the herring food. In the stomach of one herring from 3—I—34 62 individuals occurred, but in most stomachs the numbers were below 10 specimens.

9. Polychaeta.

Scanty remains of polychætes were observed in the stomachs of only two herring caught on 4—II—33 and 3—I—34.

10. Mollusca.

Strange to say larval gastropods could not be established with certainty in the herring food, and of adult individuals only one — *Littorina*-like — specimen was found in the stomach of a herring from 9—XI—33.

Young individuals of lamellibranchs were sometimes found in the herring food, occurring always in ones. They were observed in a total of 8 herring, and the shells of the largest — *Cardium*-like — bivalves had a length of 6 mm. Larval stages of bivalves were established in the food of 7 different herring samples, all dating from the time between August, 2nd, and September, 9th, i. e. from the autumn. Some few herring contained a number of larval bivalves, but in most of them only individual specimens occurred.

11. Chaetognatha.

Sagitta plays quite an inferior part as a food matter of the Bornholm herring: it was established in the stomach contents of no more than 3 herring from the months of June and July, but curiously enough all three specimens showed a rather numerous representation of *Sagitta*, the numbers ranging between 20 and 50 individuals.

12. Pisces.

Young fish were found in the food of the Bornholm herring at all seasons, their importance as a food matter, however, being limited to the months of February, March and April. At other

seasons they are of quite inferior importance in the diet of the herring. In Table 24 are given the monthly percentages of feeding herring with young fish as food.

Table 24.

Monthly percentages of feeding herring with young fish as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	—	5.0	—	—	0.3	—
1933.....	1.4	7.2	38.2	17.6	0.5	—	0.8	1.0	—	—	—	—
1934.....	6.2	12.7	95.5	..	8.1	—	1.6	—	—	—	—	4.8
1935.....	3.3	56.8	—	55.2	3.0	—	5.9	—	—	—	8.3	—
Mean...	3.6	25.6	44.6	36.4	3.9	—	2.1	1.5	—	—	2.1	1.2

We see from this survey that the time between February and April is the only period in which young fish were found as food in a comparatively large number of herring, a fact appearing even more distinctly from the graphical representation of Figure 13.

As far as possible the number of young fish found in each herring stomach was counted thus conveying an idea of the considerable quantities of young fish devoured by the herring at certain seasons. Table 25 (p. 32) brings the calculated numbers of young fish found as food per 100 feeding herring in the various months, and through a comparison with the mean figures of Table 24 we find an excellent correspondence in the fact that the importance of the young fish as herring food reveals itself principally in the months of February, March, and April, more particularly in the two last-mentioned months.

Figure 13. Monthly percentages of feeding herring with young fish as food in the years 1932—35.

In many cases the young fish found in the stomachs had become so decomposed, that a determination of species was impossible, but the great majority, no doubt at least 90%, were post-larval stages of *Ammodytes*, this species thus causing the very large numbers. Apart from *Ammodytes* youngs of *Gadus* were undoubtedly the most numerous representatives of fish in the food, especially in April when, in some samples, they constituted about 10% of the total number of young fish found in the stomach contents of the herring. Furthermore, post-larval stages

Table 25.

Average numbers of young fish found in the stomachs of 100 feeding herring in the various months.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	..	5	—	—	1	—
1933.....	1	62	653	376	6	—	1	1	—	—	—	—
1934.....	142	153	3790	..	—	—	1	—	—	—	—	100
1935.....	77	836	—	2034	8	—	6	—	—	—	15	—
Mean...	73	350	1481	1205	5	0	3	1	0	0	4	25

of *Lumpenus*, *Cottus*, and *Clupea sp.* occurred in inconsiderable numbers. The number of young fish found in one herring stomach is sometimes very high when you consider the small size of the Bornholm herring as compared for instance with the herring of the North Sea and the waters round Iceland. Several stomachs contained between 50 and 100 young fish, and the largest number in one herring stomach amounts to about 115 specimens, consisting of about 100 *Ammodytes* (20—30 mm. long), 8 *Gadus*, and some few young fish of indeterminable species.

In connexion with the facts mentioned above it is interesting to look at the conditions in other Danish waters as regards the seasons at which the herring live principally on fish food. Investigations of this kind were carried out at Rudkobing, in the Sound, at Samso, and Frederikshavn. In all these localities young fish are of principal importance as herring food late in summer and in autumn (Jespersen, 1928, p. 126), at quite another season than at Bornholm. To the North Sea herring, however, the principal period of young fish diet (*Ammodytes*) falls within the months of March, April, and May (Hardy, 1924, p. 19), or approximately the same time as was found in the case of the Bornholm herring.

Now and then herring eggs were found in the stomach contents in autumn, but always in very small numbers. Fish eggs also occurred in the herring food at other seasons, but they always appeared in ones or in so very small quantities, that they are undoubtedly of no interest in a nutritive-biological respect.

Besides these organisms elements of an apparently accidental character were sometimes met with in the herring food. Several times pebbles – the largest of them measuring 6 mm. in length and 4 mm. in breadth — were found in numbers of up to 6 pieces per stomach. One herring had a detritus-like matter in its stomach, and some contained a few feathers and other accidental objects.

VII. Summary of the Principal Elements in the Food of the Herring.

The composition of the herring food in the waters round Bornholm is subject to great variations at the different seasons. We get an idea of these variations from Figure 14, which, in a graphical form, shows the monthly percentages of feeding herring with the principal groups of

organisms as food. The calculations are based on the mean figures of the total material examined during the years 1932—35. The principal food organisms are the following groups: copepods, cladocerans, mysids, cumacea, isopods, amphipods, and of non-crustaceous food: fish.

Figure 14 shows us that the copepods were found as food in by far the largest number of herring. Between March and July (inclusive) copepods occurred in practically all herring examined. Late in autumn and especially in winter the copepods are of somewhat inferior importance as a food matter, but in no month of the year they were found as food in less than about 80 % of the feeding herring examined. Thus the copepods constitute an important item in the herring food during all months of the year, whereas the cladocerans appeared as food in a fairly large number of the herring during the warm season only, between May and October. Other crustaceans, however, especially mysids, were observed as food in the largest numbers of herring during the cold season, particularly in the period between November and February (inclusive). Cumacea, isopods, and amphipods are generally of less importance as herring food; like the mysids these three groups seem to occur as part of the herring food principally during the cold season. Fish and particularly youngs of fish show a distinct maximum in the herring food in late winter and early spring, i. e. in the months of February, March, and April, but throughout the rest of the year they are of quite inferior importance in the diet of the Bornholm herring.

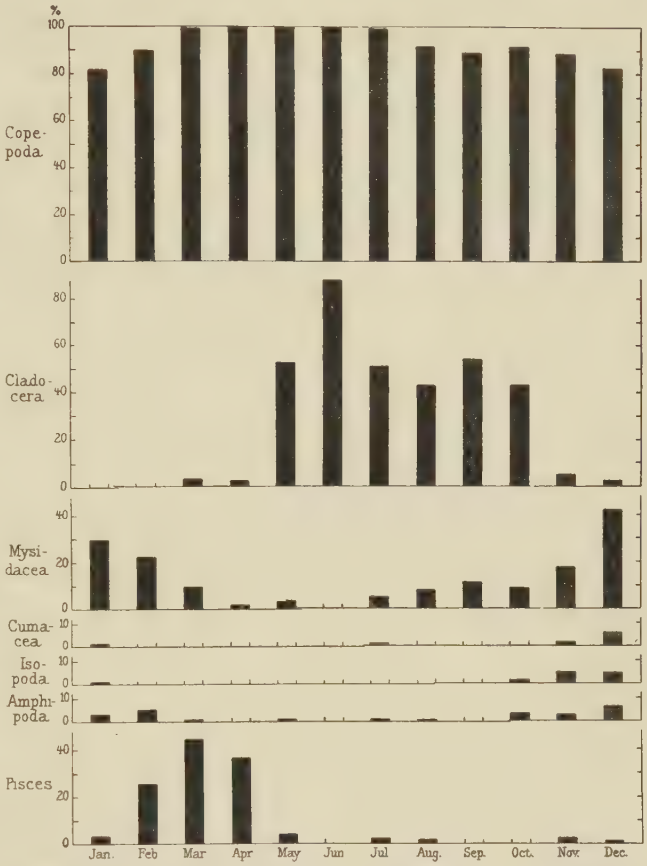

Figure 14. Monthly percentages of feeding herring with the principal groups of organisms as food.

If we sum up the facts stated above according to the different seasons, we get the following approximate distribution of the importance of the food animals:

In spring: especially copepods and young fish;
in summer: principally copepods and cladocerans;
in autumn: copepods and to some degree cladocerans;
in winter: besides copepods chiefly larger crustaceans like mysids, cumacea, isopods, and amphipods.

The fact of the larger crustaceans appearing in the food of the Bornholm herring principally during the winter half-year is illustrated by Table 26, which shows the monthly percentages of feeding herring, in which larger crustaceans like mysids, cumacea, isopods, and amphipods occurred as food.

Table 26.

Monthly percentages of feeding herring with larger crustaceans, viz. mysids, cumacea, isopods, and amphipods as food.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1932.....	..	..	..	..	..	..	4.9	20.0	2.4	23.5	30.7	36.5
1933.....	6.0	25.9	7.0	—	0.6	—	3.4	2.0	6.5	—	25.0	42.9
1934.....	28.3	29.8	18.2	..	2.5	..	1.1	11.3	18.4	20.0	16.7	71.4
1935.....	40.6	14.9	2.1	3.4	4.6	..	9.3	3.1	15.8	11.1	17.6	29.2
Mean...	25.0	23.5	9.1	1.7	2.6	—	4.7	9.1	10.8	13.6	22.5	45.0

That these crustaceans in the great majority of cases are found in the winter food of the herring appears most distinctly from Figure 15, which brings a graphical representation of the average figures of the respective months.

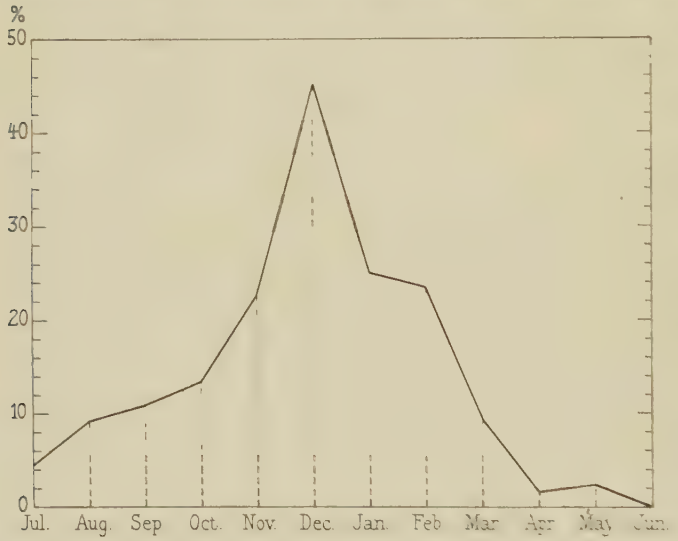

Figure 15. Monthly percentages of feeding herring with larger crustaceans, viz. mysids, cumacea, isopods, and amphipods, as food, calculated as mean figures of the total material for the respective months of the years 1932—35.

By far the greatest number of herring containing these large crustaceans is found in December, from which time the relative quantities decrease rather smoothly both towards the autumn and towards the spring. A predominance of these crustaceans is found only during the time between November and February (inclusive).

It appears from the above description that in summer the herring of the waters round Bornholm almost exclusively feed on the smaller crustaceans like copepods and cladocerans; during the better part of the winter larger crustaceans like mysids, cumacea, isopods, and amphipods are preferred. Towards the end of the winter and in early spring (February—April) we find the third important element of the herring food, the young fish, as will be seen from the graphical representation of Figure 14 (p. 33).

Tables of Stomach Analyses.

The following tables give a survey of the samples of herring stomachs examined. For each sample are stated: date and locality, number of herring examined, number of herring with stomach contents, and percentage of feeding herring. Next follows a survey of the relative quantities of feeding herring in the respective samples, containing the principal groups of food organisms.

Tables of Stomach Analyses.

Date	Position	No. of herring examined	No. of feeding herring	Percentage of feeding herring	Percentage of feeding herring containing: Copepods	Cladocerans	Mysids	Cumacea	Isopods	Amphipods	Fish youngs
1931											
Aug. 6	Davids Banke	19	8	42.1	12.5	12.5	87.5	..	..	..	..
20		15	2	13.3	100.0	50.0	..	..	..	..	..
29		15	1	6.6	100.0	..	..	..	..	..	..
Sept. 8		20	3	15.0	100.0	66.6	33.3	..	..	..	..
13		15	2	13.3	100.0	100.0	..	..	..	..	..
1932											
July 12	1 mile W. of Hammeren	88	81	93.2	100.0	3.7	4.9	1.2	..	..	..
26	?	98	80	81.6	100.0	37.5	1.2	1.2	..	1.2	..
Aug. 25	5 miles N. of Gudhjem	50	20	40.0	95.0	25.0	20.0	..	..	..	5.0
Sept. 2	4 — N.E. —	63	45	71.4	100.0	22.2	2.2	..	..	..	..
8	2 — N.W. —	59	39	66.1	100.0	66.7	2.6	..	..	..	..
20	2 — N.E. —	85	21	24.7	100.0	71.4	..	..	..	..	..
27	2 — — —	76	19	25.0	100.0	57.9	5.3	..	..	..	..
Oct. 6	2 — — —	118	34	28.8	94.1	64.7	8.8	..	2.9	14.7	..
Nov. 5	0.5 — — —	111	65	58.6	96.9	10.8	4.6	..	..	1.5	1.5
12	1.5 — — —	84	52	61.9	96.2	..	25.0	..	..	..	..
17	0.5 — — —	83	54	65.1	88.9	..	46.3	3.7	..	..	..
26	6 — N. —	139	60	43.2	80.0	..	41.7	10.0	..	..	..
Dec. 7	3 — N.E. —	53	29	54.7	62.1	..	93.1	27.6	..	..	..
16	4 — — —	68	55	80.9	100.0	..	1.8	1.8	..	..	..
30	6 — — —	51	20	39.2	85.0	..	40.0	5.0	..	..	..
1933											
Jan. 5	N.E.—N. of Gudhjem	65	15	23.1	100.0	..	13.3	6.7	..	..	..
— 16	1 mile N.E. of Gudhjem	80	79	98.7	100.0	..	..	..	..	..	..
27	4 miles N.N.E. of Gudhjem	68	23	33.8	82.6	..	26.1	..	4.3	..	4.3
Feb. 4	N.N.E. — — —	118	37	31.4	94.6	..	48.6	..	..	..	..
16	N.E. — — —	39	24	61.5	95.8	..	45.8	..	..	..	..
25	4 miles E. — — —	58	51	87.9	98.0	..	..	..	..	..	21.6
Mar. 7	0.5 — N.E. — — —	48	37	77.1	94.6	..	18.9	..	..	5.4	70.3
24	5 — E. — — —	41	39	95.1	100.0	..	..	..	..	..	17.9
30	2 — N. — — —	71	68	95.8	100.0	..	2.9	..	..	..	26.5
Apr. 11	E. — — —	41	35	85.4	100.0	..	..	..	..	..	8.6
20	3 miles E. — — —	20	20	100.0	100.0	..	..	..	..	..	25.0
29	1 — N. — — —	31	31	100.0	100.0	19.3	..	..	..	..	19.3
May 11	1 — — —	68	68	100.0	100.0	33.8	..	..	..	..	1.5
19	N. — — —	53	53	100.0	100.0	77.4	2.0	..	..	2.0	..
31	8 miles N. — — —	57	57	100.0	100.0	98.2	..	..	..	..	..
June 13	4 — W. of Hammeren	21	21	100.0	100.0	100.0	..	..	..	..	..
22	8 — W.N.W. of —	40	39	97.5	97.4	71.8	..	..	..	..	..
July 5	4 — W.S.W. of —	41	40	97.8	100.0	37.5	..	..	..	..	2.5
13	4 — N.E. of Gudhjem	40	38	95.0	100.0	60.5	..	..	..	..	..
— 25	2 — N. — — —	40	39	97.5	100.0	43.6	10.3	..	..	2.6	..
Aug. 2	8 — W. of Hammeren	40	25	62.5	96.0	28.0	4.0	..	..	..	4.0
.. 17	5 — N. of Gudhjem	40	27	67.5	96.3	37.0	3.7	..	..	..	..

Date	Position	No. of herring examined	No. of feeding herring	Percentage of feeding herring	Percentage of feeding herring containing:						
					Copepods	Cladocerans	Mysids	Cumacea	Isopods	Amphipods	Fish youngs
Aug. 21	8 miles W.N.W. of Hammeren	10	21	52.5	100.0	71.4	..	..	..	..	..
— 30	8	10	29	72.5	100.0	44.8	3.4	..	..	..	..
Sept. 12	8 W.	40	18	45.0	100.0	50.0	5.6	..	..	..	..
20	4 N.E. of Gudhjem	40	13	32.5	100.0	23.1	7.7	..	..	..	..
Oct. 11	E.	55	10	18.2	100.0	20.0	..	..	..	..	..
Nov. 9	8 miles E.	40	21	52.5	85.7	..	9.5	..	19.0	14.3	..
— 25	1 N.E.	50	27	54.0	81.5	7.4	11.1	3.7	11.1	3.7	..
Dec. 4	8 E.	41	25	61.0	76.0	..	8.0	..	28.0	40.0	..
— 16	8 N.E.	10	17	12.5	88.2	..	35.3	..	..	..	..
1934											
Jan. 3	2 miles N. of Gudhjem	38	18	47.4	77.8	..	5.6	..	5.6	22.2	..
— 13	8 N.E.	27	15	55.6	86.7	..	53.3	13.3	..	..	..
— 27	8 N.E.	42	27	64.3	100.0	..	14.8	..	..	7.4	18.5
Feb. 11	8 N.	46	12	26.1	58.3	..	25.0	..	..	8.3	8.3
— 28	2 E.	41	35	85.4	100.0	..	20.0	..	..	17.1	17.1
Mar. 10	2 N.	22	22	100.0	100.0	..	18.2	..	..	..	95.5
May 2	5 E.	38	37	97.4	100.0	19.0	..	..	..	..	32.4
11	5 N.	40	40	100.0	100.0	97.5	5.0	..	..	..	..
— 17	8 N.	40	40	100.0	100.0	97.5	5.0	..	..	..	..
— 28	8 W. of Hammeren	40	40	100.0	100.0	100.0	..	..	..	..	..
June 8	8 S.E. —	40	39	97.5	100.0	100.0	..	..	..	..	..
— 21	3 E. of Gudhjem	40	35	87.5	100.0	77.1	..	..	..	..	..
July 3	4	40	34	85.0	100.0	76.5	..	..	..	..	..
— 11	6	40	34	85.0	100.0	88.2	2.9	..	..	..	..
— 25	3	26	21	80.8	100.0	76.2	..	..	..	..	4.8
Aug. 6	4 — N.	32	23	71.9	100.0	30.4	8.7	..	..	4.3	..
— 15	5 — E.	27	21	77.8	95.2	42.9	19.0	..	..	..	..
— 25	1	20	18	90.0	27.8	100.0	..	..	..	..	..
Sept. 4	2 — N.E.	31	29	93.5	41.4	96.6	17.2	..	..	..	..
— 14	1 — N.	21	10	47.6	60.0	40.0	40.0	..	..	..	..
— 24	S.E.	34	10	29.4	80.0	50.0	..	..	..	..	..
Oct. 9	2 miles N.E.	23	6	26.1	66.7	50.0	33.3	..	..	..	..
— 20	4 — S.E.	31	4	12.9	75.0	25.0	..	..	..	..	..
Nov. 15	4 — E.	43	15	34.9	100.0	6.7	6.7	..	..	..	..
— 26	3 —	18	9	50.0	66.7	..	33.3	..	..	..	..
Dec. 31	3	29	21	72.4	76.2	..	71.4	4.8	..	..	4.8
1935											
Jan. 15	1 mile N.E. of Gudhjem	34	23	67.6	30.4	..	87.0	..	..	..	4.3
— 30	3 miles —	55	41	74.5	97.6	..	14.6	..	..	..	2.4
Feb. 11	2 — E. —	29	16	55.2	87.5	..	25.0	..	..	..	75.0
— 28	0.5 — N.	33	31	93.9	100.0	..	3.2	..	..	6.5	38.7
Mar. 14	1 — E. —	25	20	80.0	95.0	..	5.0	..	..	..	..
— 25	3 — — —	34	28	82.4	100.0	14.3	..	..	..	..	..
Apr. 8	3 — N.	29	29	100.0	96.6	..	3.4	..	..	..	55.2
May 7	5 —	66	66	100.0	100.0	..	7.6	..	..	..	6.1
— 15	7 — E. —	43	42	97.7	100.0	20.9	..	..	..	..	..

Date	Position	No. of herring examined	No. of feeding herring	Percentage of feeding herring	Percentage of feeding herring containing:						
					Copepods	Cladocerans	Mysids	Cumacea	Isopods	Amphipods	Fish youngs
June 4	6 miles N.E. of Gudhjem	42	42	100.0	100.0	100.0	..	..	..	..	..
— 11	4 — N. - —	32	32	100.0	100.0	100.0	..	..	..	..	..
— 27	6 — W. of Hammeren	26	26	100.0	100.0	69.2	..	..	..	..	..
July 12	3 — N. of Gudhjem	28	19	67.9	100.0	36.8	..	..	..	..	10.5
— 12	6 — W. of Hammeren	36	31	86.1	100.0	64.5	3.2	..	..	..	..
— 19	4 — N. of Gudhjem	38	21	55.3	100.0	23.8	14.3	..	..	..	..
— 26	4 — - - —	36	15	41.7	93.3	20.0	26.7	..	..	..	13.3
Aug. 6	5 — - - —	29	19	65.5	100.0	21.1	..	..	..	..	..
— 22	5 — - - —	30	13	43.3	92.3	61.5	7.7	..	..	..	..
Sept. 4	5 — - - —	17	8	47.1	100.0	62.5	..	..	..	..	..
— 12	5 — - - —	17	5	29.4	100.0	100.0	..	..	..	..	..
— 18	4 — - - —	23	6	26.1	82.7	33.3	50.0	..	..	..	..
Oct. 3	4 — N.E. - —	22	6	27.3	100.0	66.7	16.7	..	..	..	..
— 8	4 — N. - —	19	3	15.8	100.0	33.3	..	..	..	..	..
Nov. 1	4 — N.E. - —	20	3	15.0	100.0	..	..	..	..	..	..
— 12	3 — N. - —	29	23	79.3	100.0	26.1	8.7	4.3	..	..	..
— 29	3 — - - —	16	8	50.0	87.5	..	12.5	..	12.5	12.5	25.0
Dec. 6	3 — - - —	25	14	56.0	64.3	..	71.4	21.4	7.1	..	..
— 12	0.5 — - - —	24	22	91.7	100.0	27.3	4.5	..	..	4.5	..
— 26	3 — - - —	18	12	66.9	100.0	..	16.7	..	..	..	..

Dansk Resumé.

(Undersøgelse over Sildens Føde i Farvandet omkring Bornholm).

Da Sildefiskeriet ved Bornholm i 1931 gav et paafaldende daarligt Udbytte, idet der ikke alene fandtes forholdsvis faa Sild, men saavel disses Størrelse som Kvalitet var ringe, blev der i Aarene 1932—35 paa Initiativ af Dansk Biologisk Station foretaget systematiske Undersøgelser over Sildens Føde for at konstatere, i hvilken Grad Fødemængden og Fødens Sammensætning varierede paa forskellige Aarstider og i forskellige Aar. I dette Øjemed blev der flere Gange hver Maaned udtaget Maver af en Portion Sild, i Reglen 20—40 Stkr., og disse Prøver af Sildemaver blev indsendt til Planktonlaboratoriet til Undersøgelse. I Løbet af de nævnte Aar er Maveindholdet undersøgt paa ialt ca. 4600 Sild. Paa Kortet Fig. 1 (Side 3) er ved Skravering afsat det omtrentlige Omraade, nemlig Nord og Nordøst for Bornholm, hvorfra det undersøgte Materiale stammer. Det betydelige Arbejde med at udtage Maverne og indsende dem til Undersøgelse er med stor Velvilje og Interesse foretaget af Hr. Andreas Koch, Gudhjem.

1. Udbyttet af Sildefiskeriet ved Bornholm i Aarene 1926—35 er afsat grafisk paa Fig. 2 (Side 4), idet den skraverede Del af Søjlerne angiver Udbyttet af Fiskeriet i Maanederne Maj—August (incl.), hvor Fiskeriet især udføres med Drivgarn. Det paafaldende ringe Udbytte i 1931 og en nogenlunde jævn Stigning i Udbyttet i Aarene 1932—35 fremgaar tydeligt af den grafiske Fremstilling.

2. En Undersøgelse af det relative Antal Sild med Føde i Maven i Aarets forskellige Maaneder (Fig. 3, Side 6) viser, at praktisk talt alle Sild, der er undersøgt i Tiden fra Marts til Juli (incl.) har Føde i Maven. Om Efteraaret, særlig i Oktober Maaned, har derimod kun ca. 20—25 % af de undersøgte Sild Føde i Maven. Hen paa Vinteren tiltager den relative Mængde igen, men Antallet ligger dog kun omkring 50—60 % indtil Marts Maaned, hvor langt Størsteparten af Silden har Føde i Maven.

3. Variationer i Mængden af Sildeføde i forskellige Aar. I Eftersommeren 1931, hvor der dog kun blev undersøgt forholdsvis faa Sild, fandtes relativt langt færre Sild med Føde i Maven end paa den tilsvarende Tid i de følgende Aar. Aarsagen til, at der nævnte Aar fandtes forholdsvis faa Sild i Farvandet omkring Bornholm, og Størrelsen og Kvaliteten af denne var paafaldende ringe, skyldes derfor formentlig, at der det Aar fandtes forholdsvis færre af Sildens Fødeorganismer i Vandet end i de paafølgende Aar. Enkelte Planktonprøver indsamlet i Sommeren 1931 og 1932 tyder da ogsaa paa, at Planktonmængden i 1931 var betydeligt mindre end i 1932.

4. Fødemængden i Sildemaverne i Aarets forskellige Maaneder viser, at Silden især har store Kvantiteter af Føde i Maven i det tidlige Foraar, Marts—April, medens der om Efteraaret findes meget smaa Mængder. Naar der om Efteraaret, særlig i September—

Oktober, findes forholdsvis faa Sild med Føde i Maven, og Fødemængden er minimal, skyldes det utvivlsomt, at Silden især gyder paa den Tid af Aaret, og alt tyder paa, at Silden ved Bornholm under og umiddelbart før Gydningen kun i meget ringe Grad tager Føde til sig. De store Fødemængder i Sildens Mave i det tidlige Foraar skyldes først og fremmest, at Silden paa den Aarstid for en stor Del lever af Fiskeunger, især Unger af Tobis (*Ammodytes*).

5. Fødens Sammensætning paa de forskellige Aarstider er meget varierende. Rent kvantitativt spiller Smaakrebs som Copepoder og Cladocerer den største Rolle som Fødeorganismer for Silden, og især de førstnævnte udgør paa alle Aarstider en vigtig Bestanddel af Sildens Føde; men andre Organismer har paa visse Tider af Aaret stor Betydning. Om Sommeren og tildels om Efteraaret bestaar Føden saaledes næsten udelukkende af de nævnte Smaakrebs, men om Vinteren, hvor Copepoderne dog ogsaa er et vigtigt Fødeemne, kommer der forskellige andre og større Krebsdyr til som Fødeemner. Krebsdyr som Mysider, Cumaceer, Isopoder og Amfipoder udgør saaledes kun i Vinterhalvaaret en væsentlig Bestand af Sildeføden. Fig. 12 (Side 26) viser saaledes det gennemsnitlige Antal Mysider, der er fundet i 100 Sildemaver i Aarets forskellige Maaneder. Endelig sidst paa Vinteren og i det tidligere Foraar har foruden Copepoderne navnlig Fiskeunger, især af Tobis, en meget stor Betydning som Føde. Dette fremgaar særdeles tydeligt af Tabel 25 (Side 32), der viser Gennemsnitsantallet af Fiskeunger, der er fundet i Maven hos 100 Sild i de forskellige Maaneder.

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